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# SOIL SURVEY

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## **Crow Wing County Minnesota**

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UNITED STATES DEPARTMENT OF AGRICULTURE  
Soil Conservation Service  
In cooperation with  
MINNESOTA AGRICULTURAL EXPERIMENT STATION

## HOW TO USE THE SOIL SURVEY REPORT

**T**HIS SOIL SURVEY is partly a detailed survey and partly a reconnaissance survey. Those soils in the southwestern part of the county, where much of the agricultural development is centered, were surveyed by the detailed method. Those in the rest of the county were surveyed by the reconnaissance method. These methods are discussed in the section "How Soils Are Mapped and Classified."

### Locating soils

To find out what soils are in a specific area, first use the index to map sheets, at the back of the report, to learn on which sheet of the soil map the area is shown. Next, turn to the correct map sheet. If the area is in that part of the county covered by the detailed survey, the map sheet shows the boundaries of individual soils, and each soil is identified by a symbol. For example, the symbol BuA identifies Burkhardt sandy loam, 0 to 2 percent slopes. If the area is in the part of the county covered by the reconnaissance survey, the map sheet shows the boundaries of soil associations instead of individual soils. The soil associations are identified by symbols made up of capital letters. The symbol BCA, for example, identifies Brainerd-Chetek Association, nearly level. All of the soils and soil associations shown on the map sheets are described in the section "Descriptions of the Soils."

The part of the county that was surveyed by the reconnaissance method was mapped in part at a scale of slightly more than 3 inches to the mile and in part at a scale of 2 inches to the mile.

### Finding information

This report contains sections that will interest different groups of readers, as well as some sections that may be of interest to all.

*Farmers and those who work with farmers* can learn about the soils from the section "Descriptions of the Soils." From the section "Use and Management of the Soils for Agriculture," they can learn about management and yields. In that section the soils are placed in manage-

ment groups. All the soils in the same group need about the same management and respond in about the same way.

*Foresters and others interested in woodland* can refer to the section "Use of the Soils for Woodland," where the soils are grouped according to their suitability for specified kinds of trees and the factors affecting management of woodland are explained.

*Engineers and builders* will want to refer to the section "Engineering Applications." Tables in that section show soil characteristics that affect engineering.

*People interested in science* will find information about how the soils were formed and about the physical constitution of the soils in the section "Genesis and Morphology of the Soils."

*Students, teachers, and others* will find information about soils and their management in various parts of the report, depending on their particular interest.

*Newcomers to Crow Wing County and others who are not familiar with the county* will be interested in the sections "General Soil Map," where broad patterns of soils are described, and "General Nature of the County," which discusses climate, agriculture, and related topics.

*All readers* will find the guides to mapping units, at the back of the report, an aid in the use of the map sheets and the report. This guide lists each soil and soil association mapped in the county and the page where each is described. It also lists, for the individual soils, the management group and woodland suitability group in which each soil has been placed, and the page where each of these groupings is described. The soil associations were not placed in interpretative groups.

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Fieldwork for this survey was completed in 1957. Unless otherwise indicated, all statements in the report refer to conditions in Crow Wing County at that time. This soil survey was made cooperatively by the Soil Conservation Service and the Minnesota Agricultural Experiment Station. Soil maps of farms have been furnished to cooperators with the Crow Wing County Soil Conservation District.

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# SOIL SURVEY OF CROW WING COUNTY, MINNESOTA

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**C**ROW WING COUNTY is near the geographic center of Minnesota (fig. 1). It occupies 1,143 square miles; the land area is 999 square miles, and lakes make up 144 square miles. Brainerd, the county seat and largest city, is about 110 miles from St. Paul, the State capital.

Most of the acreage is used for the production of timber. About one-tenth is used for crops. The major crops are small grains and hay. Some corn is also grown. The many lakes make the county a favorable summer recreation area.

The county has a subhumid, continental climate. Winters are cold, and summers are only moderately warm.

## *How Soils Are Mapped and Classified*

Soil scientists made this survey to learn what kinds of soils are in Crow Wing County, where they are located,

and how they can be used. They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important distinguishing characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Brainerd and Nokay, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can, however, differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Chetek gravelly loamy sand and Chetek sandy loam are two soil types in the Chetek series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. In Crow Wing County, soil types are divided into phases primarily on the basis of slope range or degree of erosion. For example, Chetek sandy loam, 0 to 2 per-

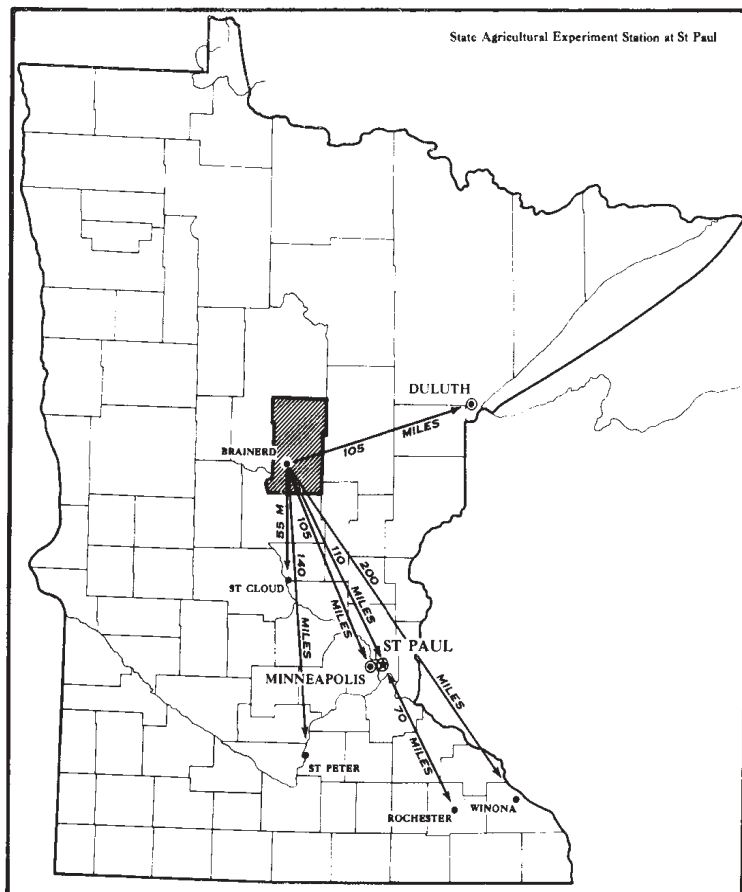


Figure 1.—Location of Crow Wing County in Minnesota.

cent slopes, is one of several phases of Chetek sandy loam, a soil type that ranges from level to steep.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the mapping units on aerial photographs. The photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries. The soil map in the back of this report was prepared from the aerial photographs.

The nature of the mapping unit depends on the kind of map prepared. On a map detailed enough to be useful in planning management of farms and fields, a mapping unit is likely to be nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

On a soil map made by the reconnaissance method, one or more soil phases, types, or even series may be placed in one mapping unit. A reconnaissance map is less suitable than a detailed map for use in farm planning, but it is useful to those who need to appraise the potential of broad areas for agriculture, forestry, or other uses.

The map of Crow Wing County was made partly by the detailed and partly by the reconnaissance method. About 140,400 acres in the southwestern part of the county was surveyed and mapped in detail, which means that locations of soil boundaries were observed throughout their course. The rest of the county was surveyed by the reconnaissance method, in which some soil boundaries were observed at intervals. The reconnaissance mapping units are groups of geographically associated soils and are called soil associations. The soil associations shown on the aerial map, however, are less inclusive than those shown on the small colored map and discussed in the section "General Soil Map."

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils occur in such small areas or in such intricate association that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Brainerd-Chetek complex, which consists mainly of Brainerd sandy loam and Chetek sandy loam. Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Alluvial land or Lake beaches, and are called land types rather than soils. Small areas of wet, sandy, severely eroded, or gullied soils may be designated on the soil map by spot symbols, as was done on the map of this county.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map,

and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them farmers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil survey reports. The soil scientists set up trial groups based on the yield and practice tables and other data and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of soils and their behavior under present methods of use and management.

## General Soil Map

After study of the soils in a locality and the way they are arranged, it is possible to make a general map that shows several main patterns of soils, called soil associations. Such a map is the colored general soil map at the back of this report. Each association, as a rule, contains a few major soils and several minor soils, in a pattern that is characteristic although not strictly uniform.

The soils within any one association are likely to differ from each other in some or in many properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general soil map shows, not the kind of soil at any particular place, but patterns of soils, in each of which there are several different kinds of soils.

Each soil association is named for the major soil series in it, but, as already noted, soils of other series may also be present. The major soils of one association may also be present in other associations, but in a different pattern.

The general map showing patterns of soils is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

Described in the pages following, and shown on the colored map at the back of this report, are the nine soil associations in this county.

### 1. Brainerd-Nokay-Barrows association

The major part of this association occurs in the Brainerd drumlin field south and east of the city of Brainerd. The drumlins are 40 to 50 feet high. The slope range is 1 to 10 percent. The dominant parent material is stony, brown, sandy till that is moderately cemented in most places. This cemented part of the soil profile is called a fragipan.

The Brainerd soils are moderately well drained; the Nokay, somewhat poorly drained or poorly drained; and the Barrows, very poorly drained. Their surface layer is primarily sandy loam.

These soils constitute a large part of the acreage in the county that is used for farming. Stones are the major obstacle to cultivation. Areas from which stones and trees have been removed are used for general farming and are fairly productive. Crops respond to lime and fertilizer.



## 2. *Hubbard association*

The main soils in this association are somewhat excessively drained, dark-colored loamy sands. They are nearly level for the most part but are sloping in small areas that surround some of the lakes and streams.

Hubbard soils are used only to a limited extent for agriculture, mostly because of droughtiness. Rye, oats, hay, and some corn and soybeans are grown on these soils. Except in very dry years, crops respond to lime and fertilizer.

## 3. *Menahga association*

This association consists mostly of light-colored soils that formed from sandy outwash or windblown sand and show only slight profile development.

These soils are used principally to grow jack pine and red pine for pulpwood. Only small areas are used for agriculture, and yields are limited by droughtiness. In places, however, the water table is high enough to supply some moisture to crops, and here yields of both forest and agricultural products are better.

In some depressions, these soils are intermixed with organic soils (peat and muck). Most such areas support reeds and sedges and have been left undisturbed.

## 4. *Nisswa-Merrifield association*

The main soils in this association are nearly level and have a surface soil and a subsoil of loamy fine sand. Below the subsoil, at a depth of 3 to 4 feet, are compact bands of finer textured material.

The Nisswa soils are well drained, and the Merrifield are somewhat poorly drained. The bands of finer textured material hold enough water to make these soils more productive than the Menahga soils. Only a small part of this association, however, is used for agriculture. Small grain, hay, and some corn are grown; these crops respond well to fertilizer.

The native vegetation consists of white pine and oak.

## 5. *Chetek-Menahga association*

This association occurs mostly in the central part of the county. The Chetek soils consist of light-colored sandy loam or loam underlain by gravel at a depth of less than 24 inches. The Menahga soils formed from moderately well sorted sand.

Very little of this association is in farms, mainly because the soils are droughty. Most of the acreage is in second-growth trees. The Menahga soils support jack pine, and the Chetek soils either aspen or scrub red oak.

## 6. *Hibbing-Zim association*

This association is characterized by rough, rolling topography. The Hibbing soils are moderately well drained, and the Zim soils somewhat poorly drained. Both formed from slightly calcareous, red, silty clay till, and both have a light-colored surface layer that is ashlike when first cultivated.

Many small areas of Chetek soils are included in that part of this association that is on the rolling hills to the west of Mille Lacs Lake. These areas are difficult to separate from areas of the major soils.

Much of this association is undeveloped. Only a small part is cultivated. Small grain and hay are the main

crops. In places trees are cut for pulpwood. The vegetation consists of aspen, white spruce, balsam fir, and various climax hardwoods.

## 7. *Brainerd-Chetek-Menahga association*

The soils in this association are nearly level to gently rolling. Each of the major soils formed from a different kind of parent material. Brainerd soils were derived from brown sandy till, Chetek soils from gravelly outwash, and Menahga soils from sorted sands.

Little or no farming is practical in this association. The acreage is covered principally with aspen and jack pine, but there are mixed stands of other kinds of trees also.

## 8. *Dean Lake-Peat-Croswell association*

This association is in the basin of glacial Lake Aitkin. It is composed of nearly level soils that have a water table near the surface.

Dean Lake soils are poorly drained, and Croswell soils are moderately well drained. Both developed from lacustrine fine sand. In many places the Dean Lake soils have a mucky surface. The peat is mainly of the reed-sedge type.

This association is undeveloped for the most part. It is little used for agriculture. The trees are of poor quality.

## 9. *Iosco-Dean Lake association*

This association occurs where glacial Lake Aitkin borders the morainic Hibbing soils.

The Iosco soils are nearly level and somewhat poorly drained; they consist of a sand cap overlying glacial till of silty clay loam texture. The Dean Lake soils are nearly level also; they are poorly drained and do not have glacial till within their profile.

There is a little agriculture in this association. Small grain and hay are the principal crops. Removal of excess water is a management problem.

# Descriptions of the Soils

This section consists of three parts. The first part describes the soil series in Crow Wing County. The second describes the mapping units in the part of the county that was surveyed and mapped in detail. The third part describes the mapping units in the part of the county covered by the reconnaissance survey. To get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the relevant soil series.

Some technical terms are used in describing soil series and mapping units because there are no nontechnical terms that convey precisely the same meaning. Many of the more commonly used technical terms are defined in the Glossary.

## Soil Series

In the pages following, the soil series are arranged alphabetically by name and described. Each description of a soil series gives characteristics that are common to all of the mapping units of that series. Differences among mapping units are explained in the descriptions

of the mapping units, or are clearly indicated by the names of the mapping units. Technical descriptions of the soil series are given in the section "Genesis and Morphology of the Soils."

### **Alluvial land**

Alluvial land is a land type that occurs on the flood plains along the major streams. It consists of sediment from many different kinds of soils and shows little or no profile development. It varies widely in drainage and in texture.

In Crow Wing County, Alluvial land is used only for hay and pasture or as a habitat for wildlife.

### **Barrows series**

The Barrows series consists of poorly drained and very poorly drained, extremely stony soils that developed from noncalcareous, brownish, sandy glacial till. In Crow Wing County, these soils occur mostly in nearly level swales or in depressions between drumlins in the drumlin field south and east of Brainerd. The native vegetation consists of willows, various sedges, and some elm and black ash trees.

Normally, in undisturbed areas, a 2- to 4-inch layer of organic material overlies the surface layer. When the organic layer is plowed under and mixed with the surface layer of mineral soil, the resulting plow layer is very dark brown to black loam or sandy loam. The surface layer abruptly overlies a layer of light grayish-brown sandy loam. This subsurface layer is 6 to 18 inches thick, and it, in turn, overlies a weakly cemented subsoil of yellowish-red to dark-brown, highly mottled sandy loam. The substratum, at a depth of about 36 inches, is dark yellowish-brown, somewhat mottled sandy loam. It very closely resembles the subsoil but is less firmly cemented.

These soils are associated with the somewhat poorly drained Nokay soils and the moderately well drained Brainerd soils.

Barrows soils are not used widely for crops; they are used mostly as permanent pasture. They are fair to good soils for pasture, but they need drainage. Surface ditches are effective in draining these soils. Undrained pastures are likely to become hummocky. Stones must be removed if pastures are to be renovated; otherwise, tillage implements cannot be used. Erosion is not a problem, because in most places the soils are nearly level and runoff is not rapid.

### **Brainerd series**

This series consists of moderately well drained, slightly stony to extremely stony soils that developed from noncalcareous glacial till. In Crow Wing County these soils occur mostly in the drumlin field south and east of the city of Brainerd. Usually they are at the top of the drumlin. They are the better drained soils in this area. The native vegetation consists largely of red oak and several varieties of aspen.

The surface layer of these soils consists of very dark brown sandy loam and is 2 to 5 inches thick. It abruptly overlies a layer of dark grayish-brown to dark-brown loamy sand or sandy loam. This subsurface layer ranges from 5 inches to more than 24 inches in thickness and grades into the brown sandy loam of the cemented subsoil, which is at a depth of 16 to 36 inches. The subsoil grades

into the brown sandy loam substratum, which is at a depth of 48 to 56 inches.

The substratum is not so firmly cemented as the subsoil. The subsoil is very hard when dry but only weakly cemented when moist. Roots cannot easily penetrate the subsoil, and in many places they branch just above it. In many places the material immediately overlying the subsoil is wet because water moves slowly into the subsoil.

Brainerd soils are associated with the somewhat poorly drained Nokay soils and the poorly drained and very poorly drained Barrows soils.

Approximately 30 percent of the acreage of Brainerd soils is cleared and in crops. The major crops are small grain and hay; corn and other cultivated crops are grown in scattered areas.

Erosion is not a serious problem, nor is water management. Care should be taken, however, to prevent washing, which would leave the cemented subsoil exposed or near the surface. Stones must be removed before these soils can be farmed. Lime and fertilizer should be applied in amounts indicated by soil tests, for many areas of these soils are acid and low in available potassium.

### **Burkhardt series**

This series consists of somewhat excessively drained, dark-colored soils that developed from noncalcareous sandy and gravelly outwash on outwash plains and stream terraces. The major areas of Burkhardt soils in Crow Wing County are along the Nokasippi River south of Brainerd. Scattered areas are north and east of the Pine River. The original vegetation was prairie grasses and scattered oak trees.

The surface layer is very dark brown to black sandy loam that is friable when moist. It grades into the subsoil, which is slightly sticky, dark-brown loamy coarse sand and gravelly loamy coarse sand. The subsoil begins at a depth of 9 to 12 inches and grades at a depth of 18 to 24 inches to the normally dark-brown, stratified sand and fine gravel of the substratum. The substratum is noncalcareous and normally is medium acid to slightly acid in reaction.

Burkhardt soils are associated with Onamia soils and Chetek soils. They are darker colored than either of the associated soils.

Surface runoff is slow because the soils are nearly level in most places. Internal drainage is moderately rapid.

Burkhardt soils are of minor extent in Crow Wing County and of minor agricultural importance. Most of the acreage is cultivated. Crops grown include small grain, corn, and pasture grasses.

### **Chetek series**

This series consists of level to rolling, moderately dark colored, well-drained to excessively drained soils that developed from noncalcareous sandy and gravelly outwash. Chetek soils make up a sizable part of the county's acreage. They occur throughout the county, mostly on outwash plains and terraces but in places on kamelike hills. The native vegetation ranges from jack pine, in the more sandy areas to aspen or red oak in the level or deep areas.

In cultivated areas, the surface layer is very dark grayish-brown to dark-brown sandy loam and is 5 to 8 inches thick. It abruptly overlies a brown sandy loam subsurface layer, which is 3 to 5 inches thick. The subsoil



is at a depth of 10 to 14 inches and is 5 to 15 inches thick; it is dark-brown to dark reddish-brown heavy sandy loam to sandy clay loam. At a depth of 18 to 20 inches it abruptly overlies the substratum, which consists of dark reddish-brown to yellowish-red, noncalcareous sand and gravel.

Chetek soils vary from place to place. For example, their surface layer ranges from loam to gravelly loamy sand, and their substratum is extremely cobbly and gravelly in some places and sandy, like that of the Menahga soils, in other places.

Chetek soils are associated with Onamia soils. They are shallower to the coarse-textured, gravelly substratum than Onamia soils, and they have a thinner and less well developed subsoil.

Because they are shallow over a gravelly and sandy substratum, these soils are likely to be droughty. Droughtiness, in fact, is the major limitation. Nevertheless, the level and nearly level areas, where runoff is slow, are used widely for agriculture.

### *Croswell series*

This series consists of nearly level to gently sloping, moderately well drained, forested soils that developed from deep, sorted, noncalcareous sand in old lake basins or along outwash flats. In Crow Wing County, these strongly acid soils occur mostly in the Lake Aitkin basin, which is north and east of Deerwood. The native vegetation consists of pine, aspen, and a shrub growth of blueberry and wintergreen.

The surface layer is grayish-brown sand and is 2 to 6 inches thick. It abruptly overlies the dark-brown sand of the subsoil. The subsoil begins at a depth of 4 to 6 inches and is 16 to 36 inches thick. It grades to the brown or grayish-brown, weakly mottled sand of the substratum, which begins 18 to 40 inches below the surface.

Surface runoff is slow. Internal water movement is rapid down to the water table, which is 4 to 6 feet below the surface. Permeability is moderately rapid to rapid.

Croswell soils are of minor extent in this county and of little importance for agricultural use or for tree production. If the soils were cleared, their water-holding capacity would have to be improved by the addition of organic matter before they would be suitable for crops.

Erosion is not a serious problem, since so little of the acreage is cultivated.

### *Dean Lake series*

This series consists of level or slightly depressed, poorly drained or very poorly drained soils that developed from deep sand at the edges of old lake basins and along streams. In Crow Wing County, these soils occur mostly in the Lake Aitkin basin, north and east of Deerwood. The vegetation consists mainly of sedges, cattails, and willows.

Normally, a 4- to 8-inch layer of black, finely granulated, well-decomposed muck or organic material covers the surface. It grades into a layer of brown or grayish-brown, highly mottled, medium to coarse sand. The subsoil is at a depth of 8 to 14 inches. It is a mixture of gray and reddish-brown to yellowish-red medium sand that is loose and strongly acid. The subsoil grades to the dark-gray to dark yellowish-brown coarse sand of the substratum.

In places, the layer of organic material may be 10 inches thick. Layers of black organic material may occur as thin, discontinuous streaks anywhere within 16 inches below the surface. These streaks may be horizontal or may be at any angle.

Surface runoff is slow. Internal water movement is slow because of a high water table, which is usually at a depth of only 8 to 16 inches. Permeability above the water table is rapid.

Dean Lake soils are associated with the moderately well drained Croswell soils. They occupy only a small acreage, and little of their area is used for agriculture. Wild hay is harvested in a few places.

### *Halder series*

This series consists of nearly level to slightly depressed, somewhat poorly drained, forested soils that developed from medium-textured materials over sandy and gravelly glacial outwash. These soils occur in slight depressions on outwash plains and on low stream terraces.

The surface layer is very dark grayish-brown loam and is 6 to 12 inches thick. It abruptly overlies a layer of light grayish-brown loam distinctly mottled with yellowish brown. At a depth of 12 to 15 inches, this subsurface layer grades into the subsoil, which consists of dark reddish-brown, gravelly sandy loam with many, prominent, reddish-gray mottles. At a depth of 24 to 42 inches, the subsoil abruptly overlies stratified, yellowish-red sand and gravel. This substratum is noncalcareous and is acid in places.

The major variations are in the texture of the surface layer, which is loam or sandy loam; the texture of the subsoil, which is gravelly sandy loam, loam, or sandy clay loam; and the depth to the underlying loose, stratified sand and gravel.

Surface runoff is slow. Internal drainage is slow because of a high water table. Permeability is moderate in the upper part and rapid in the lower part.

These soils are closely associated with the well-drained Onamia soils and the poorly drained and very poorly drained Warman soils.

Halder soils are of minor extent in Crow Wing County. Small areas of these soils are scattered among areas of the better drained Onamia and Chetek soils. They are of minor agricultural importance. They must be drained of excess water if they are to be used for crops, but they can be used as pasture or for permanent hay without being drained.

### *Hibbing series*

This series consists of moderately well drained and well drained, light-colored, forested soils that developed from slightly calcareous silty clay till. The till has been leached to a depth of about 40 inches. In Crow Wing County, Hibbing soils occur on gently undulating to rolling moraines. The slope range is 3 to 30 percent. The major areas are along the eastern border of the county near Mille Lacs Lake and to the north. Most are covered with hardwoods, including oak and maple trees, and scattered conifers, mostly white pine and red pine. Second-growth aspen and birch trees are common in some areas.

In an undisturbed area of these strongly developed soils, a 2- to 3-inch layer of undecomposed tree leaves usually covers the surface. The mineral surface layer is reddish-

gray silt loam to silty clay loam. In newly plowed fields, it has an ashlike color. This layer grades to the reddish-brown silty clay of the subsoil, which has strong, blocky structure. The subsoil is 15 to 25 or 30 inches thick. It grades to the reddish-brown silty clay of the substratum, which has a less blocky structure than the subsoil. Normally the substratum is weakly calcareous. In places it is brown or dark reddish brown instead of reddish brown.

Surface runoff ranges from medium to rapid, depending on the slope. Internal water movement usually is medium to slow. Permeability is moderately slow.

Only small areas of Hibbing soils are cultivated. Consequently, these soils have been little eroded. Most areas that are used for agriculture are used as permanent pasture or for growing hay. Legumes grow well if adequately fertilized. Hibbing soils are good producers of pulpwood. In places, they produce trees that are suitable for making matchsticks. In most places, stoniness is not a problem.

### *Hubbard series*

This series consists of dark-colored prairie soils that developed from sandy glacial outwash that is noncalcareous for the most part. These soils are leached to a depth of 4 to 6 feet in most places. They occur mainly in the vicinity of Barrows and Crow Wing, which are southwest of Brainerd. The topography generally is nearly level to gently undulating, but in some places near the edges of stream terraces it is somewhat rolling. The native vegetation is mostly scattered bur oak or clumps of jack pine and tall prairie grasses.

The surface layer is very dark brown loamy sand and is 14 to 16 inches thick. It grades to the dark-brown sand or loamy sand of the subsoil. The subsoil is 12 to 14 inches thick in most places, and it, in turn, grades to the brown, loose, single-grained, sandy outwash of the substratum.

Internal drainage and permeability are very rapid.

In Crow Wing County, Hubbard soils are of minor extent, and much of their acreage is used for general farming. Small grain is the principal crop, but some row crops and hay are grown also. Yields are fair in years that are not too dry.

Control of wind erosion is the major management problem in cultivated areas. Stripcropping in a north-south direction provides effective protection against the prevailing westerly winds. Trash tillage and rough tillage also help to control erosion.

### *Iosco series*

This series consists of somewhat poorly drained soils that developed from sandy outwash, 24 inches or less thick, over moderately fine textured, calcareous material. These soils are nearly level but have slightly convex slopes in places. They occur mostly along lakeshores and as delta deposits in old glacial lakes. The major area in Crow Wing County is in the Lake Aitkin basin, northeast of Deerwood. The native vegetation consists of willows and scattered aspen; sedges grow in the open swamps.

The surface layer is black loamy sand or sandy loam and is 2 to 4 inches thick. It overlies a 3- to 5-inch layer of light brownish-gray sand. The subsoil, which is brown, strongly mottled loamy sand, is at a depth of 5 to 8 inches. It is weakly cemented in places, and it abruptly overlies the substratum, which is grayish-brown, strongly mottled,

calcareous loam or clay loam. The depth to the substratum varies from 8 to 24 inches within short distances.

Surface runoff and internal drainage are slow. Ground water normally is between 40 and 60 inches below the surface. Permeability is rapid in the upper part of the solum and slow in the lower part.

Iosco soils are of minor extent in the county; they are not cleared, for the most part, and are little used for agriculture or for tree production. Some pulpwood is harvested. The cleared acreage is used principally for hay and as pasture.

### *Isanti series*

This series consists of very poorly drained, dark-colored soils that developed from deep sand. These soils occur mostly in slight depressions in the sandy outwash flats. In places they are on slight rises in large bogs. The native vegetation consists of willows, some alder, hazel brush, sedges, and scattered aspen.

The surface layer is black sandy loam or loamy sand. It is 8 to 10 inches thick and has a very high organic-matter content. It abruptly overlies a 4- to 6-inch layer of very dark gray, highly mottled sandy loam. This subsurface layer grades into the subsoil, a layer of dark-gray sandy loam mottled with yellowish red. The subsoil is 5 to 10 inches thick, and below it is the dark yellowish-brown to pale-brown, strongly mottled, loose, single-grained sand of the substratum. In some places the substratum is grayish brown or dark grayish brown.

Surface runoff is slow or ponded. Internal drainage is slow because of the high water table. Permeability is rapid. Normally these soils are leached of lime to a depth of more than 4 feet.

Isanti soils are associated with the excessively drained Menahga soils and the somewhat poorly drained Lino soils. In Crow Wing County, they occur throughout the areas of Menahga, Hubbard, and Nymore soils. Though widely distributed, they occupy only a small acreage. They are not important as agricultural soils, nor are they good for tree production. Very few areas are cultivated, but some are used for hay or as pasture. In areas that have been drained, some small grain and some corn are grown.

### *Lake beaches*

Lake beaches consist of sandy material from the surface downward; they show little or no profile development. In places they have no vegetation. In other places they support grasses, sedges, and some trees, generally birch.

### *Lino series*

This series consists of nearly level to very gently undulating, somewhat poorly drained soils that developed from sandy outwash. The outwash is leached to a depth of 4 or 5 feet in most places. In Crow Wing County, Lino soils are widely dispersed. They occur as slight rises within shallow depressions that contain Peat and the very poorly drained Isanti soils. Bur oak and aspen trees interspersed with grass constituted the original vegetation and still cover those areas that have not been cleared.

Lino soils have a surface layer of very dark grayish-brown to dark-brown loamy sand. This layer is 9 to 10 inches thick and is moderately high in organic-matter content. In the lower lying areas, it is very dark gray or almost black. The subsoil is an 8-inch layer of mottled



dark grayish-brown and yellowish-brown loamy sand, and the substratum is yellowish-brown, brown, or pale-olive, strongly mottled, medium or fine sand. The substratum is at a depth of 12 to 36 inches. The color and number of mottles in the subsoil and in the substratum vary widely.

Surface runoff is slow or ponded. Internal drainage is slow because of a high water table. Permeability is rapid.

Lino soils are associated with soils of the Nymore, Menahga, and Isanti series.

Lino soils are of minor extent in the county and are not important for agriculture or forestry. Undrained areas are used principally for hay and pasture. Drained areas can be used for various cultivated crops.

### ***Marsh***

Crow Wing County has many areas that are covered with water much of the time. The water is shallow, and the areas do not as a rule appear as open water. Water-tolerant reeds, sedges, and brush grow in these areas.

### ***Menahga series***

This series consists of somewhat excessively drained or excessively drained, forested soils that developed from deep, loose, noncalcareous sandy outwash. These soils have very weak horizon development. The topography ranges from nearly level to strongly sloping. Nearly level areas are much more common than strongly rolling areas. The native vegetation consisted of jack pine and scattered red pine. Second-growth trees are jack pine and some aspen and white birch. A few red oaks are found.

Menahga soils have a thin, dark-brown surface layer that is a mixture of black organic matter and bleached sand grains. This layer can have sand or loamy sand texture. It contains few roots. The subsurface layer is weakly developed. It consists of brown to dark yellowish-brown loamy sand, and it grades to the subsoil, which also is weakly developed. The subsoil consists of single-grained, yellowish-brown fine sand that is slightly cohesive in place but loose when disturbed. The substratum, which is at a depth of about 33 to 36 inches, consists of yellowish-brown, loose, single-grained sand that is slightly acid to neutral.

The amount of gravel in the profile varies widely. In some places the soil is gravel free, and in others it is as much as 25 percent gravel. Menahga soils normally are more gravelly where they adjoin Chetek soils.

Surface runoff is slow. Permeability and internal water movement are rapid.

Menahga soils are widely distributed in Crow Wing County. Little of the acreage is used for crops, but some is used as pasture. Most areas are used for growing jack pine for pulpwood and lumber.

The various mapping units of the Menahga series in Crow Wing County include some soils that would now be correlated as Zimmerman soils.

### ***Merrifield series***

This series consists of somewhat poorly drained or poorly drained, nearly level or slightly depressed soils that developed from fine and medium sand or loamy sand over very fine sand and silt of lake origin. In Crow Wing County, these soils occur mostly in the region of Lake

Edward, which is north of Brainerd. The original vegetation consisted of hardwoods and white pine. Today the vegetation is mostly aspen.

Merrifield soils have a 3- to 7-inch surface layer of very dark grayish-brown loamy sand or sand that grades into a layer of dark-brown, weakly mottled, single-grained sand. This subsurface layer is 6 to 10 inches thick, and it overlies a 10-inch layer of mottled brown, dark-brown, and yellowish-brown sand that grades, at a depth of 24 to 30 inches, to the pale-brown sand of the subsoil. The subsoil is moderately cemented in some places and only weakly cemented in others. The substratum begins at a depth of about 42 inches. It is light brownish-gray, strongly mottled loamy very fine sand, silt loam, very fine sand, fine sand, very fine sandy loam, or silt. It is either stratified or has very thin, platy structure. Its reaction is medium acid.

Surface runoff is slow. Internal water movement is rapid in the upper part of the profile and slow to very slow in the lower part. Permeability is rapid down to the substratum, and slow below that.

Merrifield soils are of minor extent in the county. They are not important for agriculture or forestry. A small part of their acreage has been cleared. It is used mostly for general farm crops, but some of it is used as pasture.

### ***Nisswa series***

This series consists of moderately well drained or well drained, nearly level to gently sloping soils that developed from fine and medium sand or loamy sand over very fine sand and silt of lake origin. In Crow Wing County, these soils occur mostly in the region of Lake Edward, which is north of Brainerd. The original vegetation consisted of hardwoods, white pine, and red pine.

In an undisturbed area, the surface normally is covered with a 2- to 3-inch layer of decomposed deciduous forest litter. Below this is a 4- to 8-inch layer of grayish-brown to dark grayish-brown, structureless, loose loamy sand or sand. At a depth of 5 to 8 inches, this layer grades to the grayish-brown to brown, loose sand of the subsoil, which, in turn, grades to stratified bands of very strongly acid, highly mottled, grayish-brown to strong-brown very fine sand, very fine sandy loam, and silt loam. These bands are at a depth of 30 to 40 inches. They vary in thickness and are weakly to strongly cemented.

Surface runoff is slow. Internal water movement is medium to slow. Permeability is rapid down to the stratified bands, and slow below that.

Nisswa soils are associated with Merrifield soils. Like Merrifield soils, they are of minor extent in the county, and they are not important for agriculture or forestry. Most of their acreage is still wooded and is set aside for lakeside building lots and for recreational purposes. The small areas that have been cleared are used for small grain, for hay, and as pasture.

### ***Nokasippi series***

This series consists of poorly drained and very poorly drained soils that developed from sand or loamy sand, 2 or 3 feet thick, over glacial till of brown, acid sandy loam to clay loam. The topography generally is slightly depressed or nearly level. The native vegetation consists of sedges, cattails, and a few black ash, willow, and elm trees.



The surface layer is 6 to 8 inches thick; it consists of black sandy loam or mucky sandy loam that is slightly acid and very high in organic-matter content. It grades into a layer of dark-gray or very dark gray loamy sand. This subsurface layer is 12 to 16 inches thick. The subsoil, which is 16 to 20 inches below the surface, consists of grayish-brown or light brownish-gray loamy sand with a few olive-colored mottles. At a depth of 30 to 48 inches, it overlies the light brownish-gray and dark reddish-brown clay loam of the substratum. The clay loam is structureless and slightly plastic to sticky; it is medium acid in reaction.

Surface runoff is slow or ponded. Internal water movement is hampered by a high water table. Permeability is rapid in the upper part of the profile and slow to very slow in the lower part.

In Crow Wing County, Nokasippi soils are associated with the moderately well drained and well drained Pomroy soils and the somewhat poorly drained Watab soils. They are of minor extent in the county. There is little agricultural development of these soils, though some areas are used as pasture. Most of the acreage is used as a habitat for wildlife.

### *Nokay series*

This series consists of nearly level to gently undulating, somewhat poorly drained or poorly drained soils that developed from brown, acid, sandy loam glacial till. In Crow Wing County, these soils are widely distributed in the brown till area south and east of Brainerd. The native vegetation consists mainly of aspen and red oak.

Nokay soils have a black, friable sandy loam to loam surface layer 4 to 6 inches thick. Its reaction is strongly acid. This layer abruptly overlies a 4- to 18-inch layer of grayish-brown sandy loam with common, fine, distinct, yellowish-brown mottles. The sandy loam in this layer is strongly acid, and it has a weak, very thin, platy structure. The subsoil consists of brown or dark-brown, weakly cemented sandy loam with many yellowish-red mottles. Normally the subsoil extends to a depth of about 36 to 48 inches. The substratum consists of dark-brown sandy loam that contains channels or balls of pinkish-gray or yellowish-red sandy clay.

Surface runoff is slow. Internal water movement is slow, and permeability is slow to very slow. The compacted or cemented sandy loam in the subsoil slows the movement of water and the penetration of roots through the profile.

Nokay soils are associated with the moderately well drained Brainerd soils and the poorly drained and very poorly drained Barrows soils. All of these soils developed from the same kind of material.

In Crow Wing County, a considerable acreage of Nokay soils is used for hay and as pasture. Drained areas are used for crops. Nokay soils, however, are stony and must be cleared of stones before being put to agricultural use.

### *Nymore series*

This series consists of moderately dark colored, excessively drained, sandy soils that occur mainly on outwash plains. These soils are level to undulating in most places and rolling in some small areas. The native vegetation

consists of jack pine, red pine, and some grass. Bur oak is common in some places.

The surface layer of these soils is gray to very dark gray, very friable to loose loamy sand or loamy fine sand. It is 6 to 12 inches thick and abruptly overlies a layer of dark grayish-brown to very dark grayish-brown loamy fine sand or loamy sand that is very friable and is slightly cohesive in place. Some profiles lack this subsurface layer. The subsoil is 14 to 18 inches below the surface. It consists of brown to dark-brown, loose, single-grained sand. It grades into the substratum, which is pale brown to very pale brown, loose, single-grained, medium acid sand.

Surface runoff is slow. Internal drainage and permeability are rapid.

Nymore soils are associated with Menahga and Hubbard soils. They are somewhat darker colored than Menahga soils and not so dark colored as Hubbard soils.

Nymore soils are not extensive in Crow Wing County, and because of their droughtiness they are not important for agriculture or forestry. Nevertheless, these soils support a fair growth of trees, especially of jack pine, and are used to some extent for the common row crops, pasture grasses, and hay. The hazard of wind erosion is an additional limitation. Trash cover, rough tillage, and field shelterbelts at right angles to prevailing winds help to control wind erosion. These practices also help to keep snow on the ground and thus to increase the moisture supply.

### *Onamia series*

This series consists of well-drained, forested soils that developed from medium-textured and moderately coarse textured material over noncalcareous sandy and gravelly outwash. These soils occur on outwash flats and stream terraces. They are level to gently undulating in most places and somewhat rolling in some areas. Originally these soils were covered with red pine and white pine; now they are in second-growth aspen and birch.

The surface layer of these soils is normally very dark grayish-brown, friable loam to sandy loam that has weak structure. It is 4 to 6 inches thick. The subsurface layer is brown to dark-brown, very friable, strongly acid sandy loam. This layer is 4 to 16 inches thick. At a depth of 18 to 24 inches, it grades to the dark-brown to dark yellowish-brown, strongly acid loam to clay loam of the subsoil. In places, the subsoil shows slight evidence of cementation. At a depth of 24 to 40 inches, the subsoil grades to the substratum, which consists of brown or dark-brown to reddish-brown, sandy and gravelly, stratified material that is loose, single grained, and medium acid.

Surface runoff is slow to medium. Internal water movement is medium to rapid. Permeability is moderately rapid in the upper part of the profile and rapid to very rapid in the lower part.

Onamia soils are associated with Chetek soils, Halder soils, and Warman soils. They are deeper to the underlying gravelly material than Chetek soils, and they are better drained than both Halder and Warman soils.

Though they occur throughout the county, Onamia soils do not occupy a large area. They are widely used for general farming. Hay, small grain, and some row crops are well suited. In dry spells crops may lack moisture because the gravelly subsoil does not hold water.

## **Peat**

Peat consists of partly decomposed plant remains. Most of the peat in Crow Wing County occurs in open wet bogs and is made up of sedges. A smaller amount is made up of woody plants, and a very small amount consists of sphagnum moss. In mapping, separations were based on the thickness of the layer of peat and texture of the underlying material, not on the composition of the peat.

Few areas of Peat are used for agriculture or forestry. Most areas are of use only as wildlife habitats.

## **Pomroy series**

This series consists of moderately well drained and well drained soils that developed under forest vegetation from a cap of well-sorted sand over noncalcareous glacial till. The topography is nearly level to gently undulating and, in some places, rolling. The original vegetation consisted of white pine, red pine, a few jack pine, and scattered hardwoods.

Pomroy soils have a 4- to 6-inch surface layer of very dark gray, very friable to loose sandy loam to loamy sand abruptly overlying a layer of dark yellowish-brown, very friable, single-grained loamy fine sand that has a few very dark gray spots. This subsurface layer is 3 to 12 inches thick. The subsoil consists of brown or dark yellowish-brown, loose, single-grained loamy sand. The depth to the lower boundary of the subsoil is ordinarily 36 inches, but it ranges from 18 to 42 inches. Below the subsoil is glacial till of slightly mottled brown to reddish-brown sandy loam that is massive, firm, and slightly acid. Within this substratum is a weakly cemented to strongly cemented pan.

Surface runoff and internal water movement are slow. Permeability is rapid in the sand cap and very slow in the substratum.

Pomroy soils are closely associated with the somewhat poorly drained Watab soils and the poorly drained and very poorly drained Nokasippi soils.

Cultivated crops are not commonly grown on Pomroy soils. Cleared areas are used mainly for hay and small grain. Scattered areas are used for corn and other field crops. Much of the acreage is in trees, mostly jack pine. The major limitations of these soils are droughtiness and susceptibility to erosion. Standard management practices are usually effective.

## **Trommald series**

This series consists of poorly drained soils that developed from neutral to calcareous, red silty clay till. These soils occur in shallow depressions. Their slope range is less than 1 percent. The native vegetation consists of sedges, alders, and willows.

Trommald soils normally have a black silt loam to silty clay loam surface layer, about 4 inches thick, abruptly overlying a 3- to 5-inch layer of gray, strongly acid, heavy loam that has very thin, platy structure and is somewhat hard when dry and firm when moist. This subsurface layer grades into the subsoil, which consists of dark-gray to olive-gray, strongly mottled, slightly acid silty clay or silty clay loam that has weak, blocky structure and is plastic or sticky when wet. The subsoil, at a depth of about 40 inches, grades into the substratum, which consists of olive-gray or brown to dark yellowish-brown, strongly mottled silty clay that has weak, angular blocky structure, is plastic to sticky when wet, and is neutral in reaction.

Surface runoff is slow, and in places it is ponded. Permeability and internal water movement are slow.

Trommald soils are associated with the moderately well drained and well drained Hibbing soils and the somewhat poorly drained Zim soils.

Trommald soils are not extensive in Crow Wing County. Most of the acreage is still in native vegetation, but some areas are used as permanent pasture. Very few areas have been drained well enough for crops, but occasionally some hay is harvested.

## **Warman series**

This series consists of poorly drained and very poorly drained soils that developed under forest vegetation. These soils generally occur in shallow depressions on outwash plains and river terraces. The slope is less than 1 percent. The native vegetation consists of willow, alder, some black spruce and elm, and some sedges and cattails.

Undisturbed Warman soils usually have a 2- to 3-inch layer of medium acid, black muck or peat on the surface. Below this is a 4- to 6-inch layer of very dark grayish-brown loam to sandy loam with few, faint, dark yellowish-brown mottles. This layer abruptly overlies a layer of light brownish-gray sandy loam with common, medium, dark-brown mottles. The sandy loam is structureless, friable, and very strongly acid. It grades to the massive, friable, strong-brown to dark reddish-brown sandy loam of the subsoil, which extends to a depth of about 28 inches. The substratum consists of single-grained, loose, medium acid, brown to dark reddish-brown coarse sand and gravel. The depth to the substratum ranges from 24 to 42 inches. Some stones and a few cobblestones may occur in the profile.

Surface runoff is slow or ponded. Internal drainage usually is impeded by a high water table. Permeability is moderate in the surface layer and rapid in the underlying gravelly material.

Warman soils are associated with the well-drained Onamia soils, the well-drained to excessively drained Chetek soils, and the somewhat poorly drained Halder soils.

In Crow Wing County, Warman soils occupy only a small acreage. They are not important for agriculture or forestry. Most of the acreage is wooded. A few cleared areas are used for hay or as pasture.

## **Watab series**

This series consists of somewhat poorly drained soils that developed from a cap of well-sorted sand overlying glacial till of brown or red sandy loam. These soils occur on the nearly level lower slopes of low drumlins near areas of sandy outwash. The original vegetation consisted of elm, alder, and some aspen.

The surface layer is friable, strongly acid, very dark brown sandy loam or loamy sand that has fine, blocky structure. It is 6 to 10 inches thick and overlies a layer of structureless, friable but slightly cohesive, brown to yellowish-brown loamy sand. This subsurface layer is about 6 inches thick. The subsoil is brown to yellowish-brown, highly mottled loamy sand to sandy loam that is massive, friable, and medium acid. It abruptly overlies the substratum, which is massive, mostly firm to slightly cemented, dark-brown to light brownish-gray sandy loam, somewhat mottled in the upper part. The



thickness of the sandy upper layers ranges from 15 inches to about 24 inches.

Surface runoff is slow. Internal water movement is rapid through the surface layer and slow through the subsoil. Permeability is rapid in the upper part of the profile and slow in the lower part.

Watab soils are associated with the moderately well drained and well drained Pomroy soils and the poorly drained and very poorly drained Nokasippi soils.

In Crow Wing County, much of the acreage of Watab soils is cleared and used as pasture. The major problem in using these soils for agriculture is the removal of excess water.

### **Zim series**

This series consists of somewhat poorly drained, wooded soils. These soils formed from silty clay or clay glacial till that is usually calcareous at a depth of about 4 feet. The topography is nearly level, with shallow depressions in places. The original vegetation consisted of red oak, white oak, aspen, some maple, and an understory of ferns.

Undisturbed Zim soils usually have a 2-inch layer of finely divided organic matter on the surface. Below this is a 1-inch layer of black, friable silt loam or silty clay loam that has very fine, granular structure and is neutral or slightly acid in reaction. This layer overlies light brownish-gray to grayish-brown, friable silt loam that has weak, platy structure and contains many roots. This layer is usually 2 to 6 inches thick. It grades into the subsoil, which consists of brown to grayish-brown, very firm, medium acid to strongly acid silty clay loam that has strong, blocky structure. The subsoil, in turn, grades into the substratum, which is massive, dark-brown to dark reddish-brown clay loam, neutral in reaction. The depth to the substratum is 30 to 40 inches, and the substratum is calcareous at a depth of about 48 inches.

Surface runoff is slow or ponded. Permeability and internal water movement are slow.

Zim soils are associated with the moderately well drained and well drained Hibbing soils and with the poorly drained Trommald soils.

In Crow Wing County, Zim soils are mostly wooded. A few cleared areas are used mainly for hay or as pasture. Wetness is a major limitation, and drainage is usually not economically feasible.

### **Mapping Units of the Detailed Survey**

Only the agriculturally developed part of the county was surveyed and mapped in detail. The soils in this part of the county are described in this subsection.

Each soil, or mapping unit, can be studied by referring to its description and to the description of the soil series to which it belongs. (The "Contents" at the beginning of this report can help the reader locate the descriptions of the soil series.) All the mapping units of one series have essentially the same kind of soil profile. Some of the differences are indicated in the name of the mapping unit. Others are explained in the description of the mapping unit.

The name of each mapping unit is followed by a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. At the end of the description

of each mapping unit, the management group for that kind of soil is shown. The management groups are described in the subsection "Management Groups of Soils."

The acreage and proportionate extent of the mapping units are shown in table 1.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Alluvial land.....	692	0.5
Barrows loam and sandy loam.....	7,210	5.1
Brainerd sandy loam, 0 to 2 percent slopes..	8,208	5.8
Brainerd sandy loam, 2 to 7 percent slopes..	20,745	14.8
Brainerd sandy loam, 7 to 13 percent slopes..	1,894	1.3
Brainerd-Chetek complex, 2 to 7 percent slopes.....	199	.1
Brainerd-Chetek complex, 7 to 13 percent slopes.....	351	.2
Burkhardt sandy loam, 0 to 2 percent slopes.....	199	.1
Burkhardt sandy loam, 2 to 7 percent slopes.....	153	.1
Chetek gravelly loamy sand, 0 to 2 percent slopes.....	183	.1
Chetek sandy loam, 0 to 2 percent slopes.....	1,772	1.3
Chetek sandy loam, 2 to 7 percent slopes.....	3,391	2.4
Chetek sandy loam, 7 to 13 percent slopes.....	1,008	.7
Chetek sandy loam, 13 to 18 percent slopes.....	138	.1
Chetek sandy loam, 18 to 30 percent slopes.....	15	( <sup>1</sup> )
Halder loam.....	2,689	1.9
Hibbing silt loam, 2 to 7 percent slopes.....	474	.3
Hibbing silt loam, 7 to 13 percent slopes.....	260	.2
Hubbard loamy sand, 0 to 2 percent slopes.....	4,476	3.2
Hubbard loamy sand, 0 to 2 percent slopes, moderately wind eroded.....	31	( <sup>1</sup> )
Hubbard loamy sand, 2 to 7 percent slopes.....	3,498	2.5
Hubbard loamy sand, 7 to 13 percent slopes.....	168	.1
Iosco loamy sand, shallow.....	8	( <sup>1</sup> )
Isanti sandy loam.....	1,787	1.3
Lake beaches.....	107	.1
Lino loamy sand.....	2,969	2.1
Menahga loamy sand and sand, 0 to 2 percent slopes.....	2,715	1.9
Menahga loamy sand and sand, 2 to 7 percent slopes.....	6,078	4.3
Menahga loamy sand and sand, 7 to 13 percent slopes.....	2,001	1.4
Marsh.....	2,811	2.0
Nokasippi sandy loam.....	749	.5
Nokay sandy loam, 0 to 2 percent slopes.....	17,537	12.5
Nokay sandy loam, 2 to 7 percent slopes.....	1,268	.9
Nymore loamy sand, 0 to 2 percent slopes.....	4,766	3.4
Nymore loamy sand, 2 to 7 percent slopes.....	5,560	4.0
Nymore loamy sand, 7 to 13 percent slopes.....	718	.5
Onamia sandy loam, 0 to 2 percent slopes.....	4,125	2.9
Onamia sandy loam, 2 to 7 percent slopes.....	1,848	1.3
Onamia sandy loam, 7 to 13 percent slopes.....	122	.1
Peat, deep.....	6,981	5.0
Peat, moderately shallow over clays.....	1,130	.8
Peat, moderately shallow over sands.....	7,439	5.3
Pomroy loamy sand, 0 to 2 percent slopes.....	1,176	.8
Pomroy loamy sand, 2 to 7 percent slopes.....	2,398	1.7
Pomroy loamy sand, 7 to 13 percent slopes.....	367	.3
Pomroy loamy sand, 13 to 18 percent slopes.....	31	( <sup>1</sup> )
Warman loam.....	1,222	.9
Watab loamy sand.....	2,107	1.5
Zim silty clay loam.....	31	( <sup>1</sup> )
Gravel pits.....	40	( <sup>1</sup> )
Mines and dumps.....	4,562	3.2
Total.....	140,407	100.0

<sup>1</sup> Less than 0.1 percent.



**Alluvial land (Ad).**—This mapping unit is of minor extent. It is most extensive along the Mississippi River and the Nokasippi River, but it also occurs along many other streams. It is a mixture of many soils. Within a short distance are areas of sand and of peat and muck.

Alluvial land is used principally as a habitat for wildlife, but in areas where agriculture is prevalent it is used as permanent pasture. (Management group 15, capability subclass Vw.)

**Barrows loam and sandy loam (Ba).**—These soils occur with Brainerd soils and Nokay soils in very poorly drained areas. They are not used extensively for crops, because of wetness and stoniness. They are used mostly as permanent pasture. (Management group 13, capability subclass IVw.)

**Brainerd sandy loam, 0 to 2 percent slopes (BbA).**—This soil occurs mostly on very gentle slopes in the Brainerd drumlin field. It is, in some areas, more mottled than the Brainerd soils that occur on the stronger slopes. In many places it adjoins the somewhat poorly drained Nokay soils.

This is not an extensive soil. Areas in the southern part of the county are used for a variety of general farm crops commonly grown in the county, including hay, small grain, and some corn. Areas to the north are in second-growth trees, since that part of the county is little used for crops. (Management group 1, capability subclass IIe.)

**Brainerd sandy loam, 2 to 7 percent slopes (BbB).**—This is the most extensive Brainerd soil in the county. It is very prominent in the drumlin field south and east of Brainerd, and it also occurs in the northern part of the county. It is eroded only in scattered spots.

This soil makes up much of the cultivated acreage in the county. It is used mostly for general farming. About half of the area is in hay or is used as pasture; one-fourth is in small grain; and the remainder is in corn or other intertilled crop. (Management group 1, capability subclass IIe.)

**Brainerd sandy loam, 7 to 13 percent slopes (BbC).**—Only scattered areas of this soil are present in the part of the county that was surveyed in detail. Most of these areas are in second-growth trees, including aspen and red oak. Some areas are used as pasture, and a few others are used for hay. (Management group 4, capability subclass IIIe.)

**Brainerd-Chetek complex, 2 to 7 percent slopes (BcB).**—The Brainerd soil in this complex has a profile similar to that of Brainerd sandy loam, and the Chetek soil, a profile similar to that of Chetek sandy loam. Gravel pits occur in a few places.

Only scattered areas of this complex are present, and these areas are not agriculturally important. Some areas are farmed along with the surrounding Brainerd soils. (Management group 5, capability subclass IIIe.)

**Brainerd-Chetek complex, 7 to 13 percent slopes (BcC).**—Only scattered areas of this complex were mapped, and these areas are not agriculturally important. Most areas are left in trees, but some are farmed along with surrounding soils that developed from glacial till. (Management group 11, capability subclass IVe.)

**Burkhardt sandy loam, 0 to 2 percent slopes (BuA).**—This is the most common Burkhardt soil in the part of the county covered by the detailed survey. Its profile very

closely resembles the one described as typical of the Burkhardt series. Most areas are used for agriculture. Yields are sometimes affected by drought. Normally, erosion is not a serious problem, because the soil is nearly level. A suitable rotation consists of hay or pasture half of the time, corn or a similar cultivated crop one-fourth of the time, and a small grain one-fourth of the time. (Management group 7, capability subclass IIIs.)

**Burkhardt sandy loam, 2 to 7 percent slopes (BuB).**—This soil occurs as scattered areas surrounded by the more extensive Burkhardt sandy loam, 0 to 2 percent slopes. Both soils occur in the same fields, though not in equal proportions, and are used for the same crops. The same management practices are applied to both soils, since it would be difficult to do otherwise. Erosion is not a serious hazard, because water infiltrates rapidly. (Management group 5, capability subclass IIIe.)

**Chetek gravelly loamy sand, 0 to 2 percent slopes (CgA).**—This is only a minor soil in the part of the county that was mapped in detail. It is more extensive in the northern two-thirds of the county, the part covered by the reconnaissance survey. This soil differs from the typical Chetek soil in that it has a more gravelly surface, a coarser textured surface layer and subsoil, and a low water-holding capacity. In many places it closely resembles the Menahga soils, though it is somewhat more gravelly.

Normally, this soil is left in forest of jack pine and other species. If put to agricultural use, it is best used as pasture. (Management group 12, capability subclass IVs.)

**Chetek sandy loam, 0 to 2 percent slopes (ChA).**—This is the most extensive Chetek soil in the county. Many areas of it are used for agriculture. Droughtiness is the major management problem. Because of a gravelly subsoil, this soil does not hold enough moisture to sustain crops during the summer. Consequently, yields are low in dry years. A suitable rotation consists of hay and pasture half of the time, corn or a similar cultivated crop one-fourth of the time, and oats or wheat one-fourth of the time.

Stones and boulders are scattered on the surface in places. These must be removed before the soil can be cultivated. (Management group 7, capability subclass IIIs.)

**Chetek sandy loam, 2 to 7 percent slopes (ChB).**—This is the second most extensive Chetek soil in the county. Like Chetek sandy loam, 0 to 2 percent slopes, it is widely used for agriculture; the same rotation is suitable for both soils. Erosion is not a serious problem, because water infiltrates rapidly. (Management group 5, capability subclass IIIe.)

**Chetek sandy loam, 7 to 13 percent slopes (ChC).**—There are only scattered areas of this soil. Many have a "knob and kettle" type of topography. In most places the underlying gravel is nearer the surface than in the typical Chetek soil.

Normally, this soil is not cultivated, but it is used extensively as pasture. (Management group 11, capability subclass IVe.)

**Chetek sandy loam, 13 to 18 percent slopes (ChD).**—This soil is of minor extent and, as a rule, is not used for agriculture. It is only about 12 inches deep over sand and gravel. It is droughty, and if it were cultivated the erosion hazard would be severe. Much of the acreage sup-

ports jack pine, which can be harvested when mature. (Management group 16, capability subclass VIe.)

**Chetek sandy loam, 18 to 30 percent slopes** (ChE).—This soil occurs only as scattered areas. It is not used for agriculture. For the most part it remains in native forest consisting of jack pine. (Management group 18, capability subclass VIIe.)

**Halder loam** (Hd).—This soil is of minor extent. It occurs mostly in slight depressions and is closely associated with Chetek and Onamia soils. It is somewhat poorly drained and usually is more productive than the excessively drained Chetek soils. Most of the acreage is cultivated. (Management group 3, capability subclass IIw.)

**Hibbing silt loam, 2 to 7 percent slopes** (HbB).—In the part of the county that was surveyed in detail, this soil occurs only as small areas. It is not widely used for agriculture. Under good management, the farmed areas produce acceptable yields of the general farm crops. This soil is well suited to aspen, spruce, and balsam fir. (Management group 2, capability subclass IIe.)

**Hibbing silt loam, 7 to 13 percent slopes** (HbC).—This soil is of minor extent. It is generally not used for agriculture, but some hay and pasture crops are grown. It is well suited to aspen, spruce, and balsam fir. (Management group 6, capability subclass IIIe.)

**Hubbard loamy sand, 0 to 2 percent slopes** (HuA).—This is the most extensive Hubbard soil in the county. It occurs mostly southwest of Brainerd, in the vicinity of Barrows and Crow Wing. It is widely used for agriculture. Rye or other small grain is the principal crop, but some hay and pasture grasses are grown, and also some corn, soybeans, and other intertilled crops.

Droughtiness is a major management problem, and wind erosion can be a serious hazard in a dry year. (Management group 12, capability subclass IVs.)

**Hubbard loamy sand, 0 to 2 percent slopes, moderately wind eroded** (HuA2).—This soil occurs in scattered places within the areas of other Hubbard soils. As a result of wind erosion, it has a somewhat shallower surface layer than the surrounding soils. Sandy material has accumulated along fence lines and in fence rows.

This soil is widely used for small grains and to a lesser extent for intertilled crops. Normally, it does not produce as much as Hubbard loamy sand, 0 to 2 percent slopes, a noneroded soil.

Field shelterbelts and stripcropping are effective in controlling wind erosion. (Management group 12, capability subclass IVs.)

**Hubbard loamy sand, 2 to 7 percent slopes** (HuB).—This soil occurs as small areas within larger areas of other Hubbard soils. Some of the areas are along the edges of outwash pits or on escarpments along the Mississippi River.

Where it occurs in the same field with Hubbard loamy sand, 0 to 2 percent slopes, this soil is farmed in much the same manner and used for the same crops as the nearly level phase.

Water erosion is not a serious problem, because of the rapid permeability of this soil. (Management group 12, capability subclass IVs.)

**Hubbard loamy sand, 7 to 13 percent slopes** (HuC).—This soil occurs as small areas intermingled with the Hubbard soils of lesser slopes. Although it is ordinarily not cultivated, a few areas are used for general farm crops

along with the more gently sloping Hubbard soils, for it would be difficult to manage them separately. Erosion is not a serious problem, because the soil is very rapidly permeable and runoff does little damage. (Management group 17, capability subclass VIIs.)

**Iosco loamy sand, shallow** (Io).—This soil is of minor extent in the part of the county that was surveyed in detail. It is suited to the general farm crops grown in the area and to trees that need an abundant supply of moisture to grow well. (Management group 9, capability subclass IIIw.)

**Isanti sandy loam** (Is).—This soil is not extensive in Crow Wing County, and little of it is used for agriculture. It cannot be cultivated unless excess water is removed, but it can be used for wild hay and, in places, as pasture. Some of the lower lying areas adjacent to areas of peat or marsh may become hummocky if used as pasture. (Management group 13, capability subclass IVw.)

**Lake beaches** (lb).—This land type borders many of the lakes in the county. It consists of sand from the surface downward and shows little or no profile development. It is not used for agriculture and has no potential for agriculture or for trees. (Management group 12, capability subclass IVs.)

**Lino loamy sand** (Lo).—In some places this level and nearly level, somewhat poorly drained soil is intermixed with the somewhat excessively drained Hubbard, Menahga, and Nymore soils. In other places it is adjacent to the poorly drained Isanti soils. It is a good soil for hay and for pasture, and it can be used for small grain with moderate success. Because of a higher available moisture capacity, it is more productive than the associated somewhat excessively drained soils. It can be excessively wet where it is adjacent to the poorly drained Isanti soils. (Management group 9, capability subclass IIIw.)

**Marsh** (Mr).—This land type is poorly drained. It is best used as a wildlife habitat. During very dry seasons some areas may be used for wild hay or pasture. (Management group 19, capability subclass VIIIw.)

**Menahga loamy sand and sand, 0 to 2 percent slopes** (MaA).—Menahga loamy sand and Menahga sand are so intermingled in some areas, mostly southwest of Brainerd, that they are mapped together. Most of the acreage is used for production of jack pine; only a small part is used for agriculture. These soils are very droughty; consequently, crop yields are very low. Erosion is not a serious problem, because the soils are rapidly permeable. (Management group 12, capability subclass IVs.)

**Menahga loamy sand and sand, 2 to 7 percent slopes** (MaB).—These soils occur with Menahga loamy sand and sand, 0 to 2 percent slopes, in the jack pine area southwest of Brainerd. They are not good agricultural soils, and little or none of the acreage is used for agriculture. Jack pine production is carried on with moderate success. (Management group 12, capability subclass IVs.)

**Menahga loamy sand and sand, 7 to 13 percent slopes** (MaC).—These soils occur mostly near the city of Brainerd, in an area along the Mississippi River. They are so intermingled that it is not practical to map them separately. They are used for timber but not for crops; some areas are being used for urban development in Brainerd. (Management group 17, capability subclass VIIs.)

**Nokasippi sandy loam** (Nk).—This soil occurs only as scattered areas, most of which are along drainageways



in areas of the better drained Pomroy soils. Little or none of the acreage is used for cultivated crops; most of it is used for permanent hay or pasture. Some areas that border areas of peat may become hummocky if used as pasture. (Management group 13, capability subclass IVw.)

**Nokay sandy loam, 0 to 2 percent slopes (NoA).**—This is the most extensive Nokay soil in the county. It occurs on the lower slopes and in the higher drainageways in the Brainerd drumlin field. This soil is too stony and in places too wet for agricultural use. Where it has been cleared of stones and drained of excess water, it is used widely for permanent pasture or hay. Small grain, corn, and other cultivated crops are also grown. The excess water can be removed by means of surface ditches. (Management group 3, capability subclass IIw.)

**Nokay sandy loam, 2 to 7 percent slopes (NoB).**—Because of the impervious nature of the subsoil and the substratum, this soil is somewhat poorly drained or poorly drained. During certain periods it is too wet for tillage and for good agricultural production. It is normally used and managed about the same as the surrounding Brainerd soils. (Management group 3, capability subclass IIw.)

**Nymore loamy sand, 0 to 2 percent slopes (NyA).**—This is the most common Nymore soil in the county. The largest area is west of Barrows, which is southwest of Brainerd. Most of the acreage is in trees, generally either scrub oak or jack pine, but some areas are used for agriculture. Hay, small grain, and corn are the major crops. This soil is low in productivity because it has low water-holding capacity. Wind erosion is a major hazard in cultivated areas, but it can be controlled by means of field strips and shelterbelts. (Management group 12, capability subclass IVs.)

**Nymore loamy sand, 2 to 7 percent slopes (NyB).**—This soil is associated with Nymore loamy sand, 0 to 2 percent slopes, and is used and managed in about the same way. It makes up only a small part of the acreage of Nymore soils in the county. (Management group 12, capability subclass IVs.)

**Nymore loamy sand, 7 to 13 percent slopes (NyC).**—This soil occurs as small areas scattered on breaks between the outwash flats and the Mississippi River. Normally, it is not cultivated, but in some areas it is used as permanent pasture. Most of this soil is used for production of trees, generally jack pine. (Management group 17, capability subclass VIIs.)

**Onamia sandy loam, 0 to 2 percent slopes (OnA).**—This is the most extensive Onamia soil in the county. It is used mostly for agriculture and produces fair yields of general farm crops. In summer, when rains are infrequent, lack of moisture may cause damage to crops. Erosion is not a major problem, because this soil is nearly level and highly permeable. (Management group 7, capability subclass IIIIs.)

**Onamia sandy loam, 2 to 7 percent slopes (OnB).**—This soil is commonly associated with Onamia sandy loam, 0 to 2 percent slopes, around old kettle holes and on slight rises. In places, it is slightly shallower than the nearly level soil. Normally, the two soils are farmed together. (Management group 5, capability subclass IIIe.)

**Onamia sandy loam, 7 to 13 percent slopes (OnC).**—This is the least extensive Onamia soil in the county. It occurs on breaks and terrace escarpments and is best used

for permanent pasture, permanent hay, or timber production. In most places, this soil is only 24 to 26 inches deep to gravel. In a few places it is much like a Chetek soil in profile characteristics. (Management group 11, capability subclass IVe.)

**Peat, deep (Pa).**—This mapping unit consists of peat deposits that are more than 36 inches deep to underlying mineral materials. The Peat formed in some places from sedges; in other places from woody materials; and in a few widely scattered areas from sphagnum moss. Very few areas of Peat are used for agriculture. Some of the better drained ones are used for permanent hay. Most areas are used for recreational purposes and as wildlife habitats. (Management group 14, capability subclass IVw.)

**Peat, moderately shallow over clays (Pc).**—This mapping unit consists of peat deposits less than 36 inches deep to underlying clay or other fine-textured material. It is used and managed in much the same way as Peat, deep. A slightly greater proportion of this unit, however, is used for permanent hay or permanent pasture. (Management group 14, capability subclass IVw.)

**Peat, moderately shallow over sands (Pg).**—This is a common mapping unit in Crow Wing County. It consists of peat deposits less than 36 inches deep to underlying sand or outwash material. It is used and managed in much the same way as the other mapping units of Peat in the county. (Management group 15, capability subclass Vw.)

**Pomroy loamy sand, 0 to 2 percent slopes (PoA).**—This soil occurs as scattered areas where outwash soils of the Menahga series grade into till soils of the Brainerd and Nokay series. Most of the areas are used for the production of trees, generally jack pine, but some are used for agricultural production. Hay, small grain, and intertilled crops, including corn, are the principal crops. Droughtiness and susceptibility to wind erosion are the major limitations. (Management group 8, capability subclass IIIIs.)

**Pomroy loamy sand, 2 to 7 percent slopes (PoB).**—This soil is about as extensive as Pomroy loamy sand, 0 to 2 percent slopes, and it too is used to some extent for producing general farm crops. Water erosion is not a serious problem, because the surface layer of this soil is rapidly permeable. (Management group 8, capability subclass IIIIs.)

**Pomroy loamy sand, 7 to 13 percent slopes (PoC).**—This is not a good agricultural soil. It is used mainly for tree production. Jack pine is dominant; hardwoods and broadleaf trees, including aspen and oak, grow in some places. (Management group 11, capability subclass IVe.)

**Pomroy loamy sand, 13 to 18 percent slopes (PoD).**—This soil occurs only as scattered areas, most of which are in trees. It is a moderately good soil for jack pine but has little or no agricultural value. (Management group 16, capability subclass VIe.)

**Warman loam (Wa).**—This soil is poorly drained and very poorly drained. Most of its area is covered with willows and sedges. If the excess water is removed, this soil is moderately good for crops. In drier years, undrained areas can be used for hay and pasture. (Management group 13, capability subclass IVw.)



**Watab loamy sand (Wt).**—This is a somewhat poorly drained soil that occurs only as small scattered areas. It is associated with Lino soils and is managed in much the same way. It has fair moisture-supplying capacity because of a high water table. This soil is used mostly for permanent hay and pasture, though it has been used successfully for small grain and intertilled crops. (Management group 9, capability subclass IIIw.)

**Zim silty clay loam (Zc).**—This soil is of very minor extent in the part of the county that was surveyed in detail. Unless it is drained, it is usually too wet for general farm crops; therefore, it is best used for grass, hay, or pasture. Pasture yields are fairly good because of the favorable moisture supply. Aspen, spruce, and balsam fir grow fairly well. In places a high water table may somewhat restrict tree growth. (Management group 10, capability subclass IIIw.)

## Mapping Units of the Reconnaissance Survey

Only a reconnaissance survey was made of the part of the county that is largely undeveloped. In reconnaissance mapping, the soil boundaries are plotted from observations made at intervals and not necessarily throughout their whole course. The soils are identified, defined, and named as in a detailed soil survey. The mapping units, however, are mostly geographic associations of soils. An association may contain several sharply contrasting soil phases, types, or even series. Each association is named for the dominant soils in it. Other soils, of minor extent, may occur within the association. The dominant soils can be expected to occur in every delineated area of their association; the minor soils cannot.

Each soil association of the reconnaissance part of the soil survey can be identified on the soil map at the back of this report by its symbol, which is also shown in parentheses following the name of each association in the descriptions that follow. These soil associations are less inclusive than those on the small-scale general soil map that is printed in colors.

Most of the soils in the area covered by the reconnaissance survey occur also in the southwestern part of the county, the area covered by the detailed survey. Thus, additional information about the individual soils that make up each soil association can be found in the descriptions of mapping units of the detailed survey and in the descriptions of the soil series.

The acreage and proportionate extent of the mapping units of the reconnaissance survey are shown in table 2.

**Alluvial land (AD).**—This mapping unit includes all of the first bottoms in the part of the county covered by the reconnaissance survey. It is a mixture of mineral soils, organic soils, and marsh. Most areas are along the Mississippi River, the Pine River, and the Little Pine River, but scattered areas are elsewhere.

Alluvial land is used principally as a habitat for wildlife. Only in those parts of the county that are agriculturally well developed is it used as permanent pasture.

**Brainerd-Chetek Association, nearly level (BCA).**—This mapping unit consists of Brainerd soils, which developed from till, and Chetek soils, which developed from outwash gravel. Brainerd soils make up approximately 40 percent of this association, Chetek soils approximately 40 percent, and other soils make up the rest.

TABLE 2.—*Approximate acreage and proportionate extent of the mapping units*

Mapping unit	Acres	Percent
Alluvial land.....	5, 735	1. 1
Brainerd-Chetek Association, nearly level.....	4, 569	. 9
Brainerd-Chetek Association, undulating.....	42, 533	8. 5
Brainerd-Chetek Association, rolling.....	7, 562	1. 5
Brainerd-Nokay Association, undulating.....	27, 695	5. 6
Brainerd-Nokay Association, rolling.....	1, 394	. 3
Chetek-Onamia Association, nearly level.....	36, 392	7. 3
Chetek-Onamia Association, undulating.....	43, 418	8. 7
Chetek-Onamia Association, rolling.....	16, 114	3. 2
Dean Lake-Croswell Association, nearly level.....	990	. 2
Dean Lake-Peat Association.....	4, 972	1. 0
Hibbing Association, undulating.....	15, 044	3. 0
Hibbing Association, rolling.....	1, 231	. 2
Hibbing-Chetek Association, undulating.....	34, 362	6. 9
Hibbing-Chetek Association, rolling.....	23, 233	4. 7
Hubbard Association, nearly level.....	917	. 2
Hubbard Association, undulating.....	31	( <sup>1</sup> )
Hibbing-Zim Association, nearly level.....	2, 686	. 5
Iosco-Dean Lake Association.....	3, 800	. 8
Lake beaches.....	138	( <sup>1</sup> )
Lino-Peat Association.....	13, 015	2. 6
Menahga-Croswell Association, nearly level.....	1, 166	. 2
Menahga-Nymore Association, nearly level.....	52, 385	10. 5
Menahga-Nymore Association, undulating.....	21, 480	4. 3
Menahga-Nymore Association, rolling.....	2, 464	. 5
Marsh.....	21, 024	4. 2
Nokay-Brainerd Association, nearly level.....	24, 925	5. 0
Nisswa-Merrifield Association.....	7, 555	1. 5
Nokay-Peat Association.....	19, 678	3. 9
Nokay-Warman-Peat Association.....	1, 738	. 3
Peat.....	14, 766	3. 0
Trommald-Peat Association.....	25, 618	5. 1
Warman-Halder-Peat Association.....	20, 323	4. 1
Total.....	498, 953	100. 0

<sup>1</sup> Less than 0.1 percent.

**Brainerd-Chetek Association, undulating (BCB).**—In this association the normal slope range is 5 to 13 percent. Brainerd soils make up about 40 percent of the area, Chetek soils about 40 percent, and other soils make up the rest.

**Brainerd-Chetek Association, rolling (BCC).**—This association has a slope range of 7 to 18 percent. Brainerd soils make up approximately 30 percent of the area, Chetek soils approximately 50 percent, and other soils make up the rest.

**Brainerd-Nokay Association, undulating (BNB).**—This association occurs on the more gentle slopes in various drumlin fields. The slope range is 1 to 8 percent. Brainerd sandy loam makes up about 60 percent of the acreage, Nokay sandy loam about 25 percent, and Pomroy, Watab, Barrows, and other soils make up the rest.

**Brainerd-Nokay Association, rolling (BNC).**—In the part of the county covered by the reconnaissance survey, this association takes in most of the more strongly sloping areas. The slope range is 5 to 15 percent but is predominantly 10 to 15 percent. Brainerd sandy loam makes up about 80 percent of this association, Nokay sandy loam about 10 percent, and Pomroy, Barrows, and Watab soils make up the rest.

**Chetek-Onamia Association, nearly level (COA).**—This mapping unit consists of broad, nearly level, outwash

soils that are underlain by gravelly, noncalcareous material. These are forested soils that have a light-colored surface layer. The normal slope range is 0 to 2 percent, but some areas have slopes of up to 4 percent.

The Chetek soils make up approximately 70 percent of this association, the Onamia soils approximately 20 percent, and other soils make up the rest.

**Chetek-Onamia Association, undulating (COB).**—In this association the normal slope range is 3 to 8 percent. Chetek soils make up about 70 percent of the area, Onamia soils about 20 percent, and associated soils make up the rest.

**Chetek-Onamia Association, rolling (COC).**—This association consists of the more hilly areas of gravelly outwash. The normal slope range is 7 to 20 percent, but some areas have slopes of up to 30 percent. Chetek soils are the most extensive; they make up 75 to 80 percent of the association. Onamia soils make up about 10 percent, and other soils make up the rest.

**Dean Lake-Croswell Association, nearly level (DCA).**—This association occupies a small area in the Lake Aitkin basin, which is northeast of Deerwood. Normally, this area is little used for crops. Most of it is in wild hay, in pasture, or in woods. Dean Lake soils make up about 25 to 30 percent of the area, Croswell soils 25 to 30 percent, and other soils make up the rest.

**Dean Lake-Peat Association (DP).**—This association occupies the wetter, more poorly drained areas in the Lake Aitkin basin. The Dean Lake soils in the association have a shallow coat of peat on the surface. They make up about 40 percent of the association. Peat, moderately shallow over sand, makes up 40 percent, and Peat, deep, the remaining 20 percent. Peat occurs in the lower areas.

The soils in this association have not been developed for agricultural production. Possibly they could be used for potatoes, garden vegetables, including celery, and other specialized crops, if the excess water were removed.

**Hibbing Association, undulating (HAB).**—This association occurs mostly in the eastern half of the county. It extends to the west of Mille Lacs Lake, as far east as Deerwood and Crosby, and north to Roosevelt. The slope range is 3 to 9 percent. Hibbing silt loam makes up about 70 percent of the association, Zim soils about 15 percent, Trommald soils about 10 percent, and other soils make up the rest. The Trommald soils occur in many small, shallow depressions within the association.

**Hibbing Association, rolling (HAC).**—This association occurs in a morainic area where the slope range is 6 to 20 percent or more. Hibbing soils make up approximately 70 percent of the area, Zim soils 5 to 10 percent, Trommald soils 10 percent, and other soils make up the rest.

**Hibbing-Chetek Association, undulating (HCB).**—This association consists of Hibbing soils, which overlie clay till, and Chetek soils, which overlie gravelly outwash, as they occur in the highly morainic areas in the county. The normal slope range is 2 to 8 percent. Hibbing soils make up approximately 50 percent of the association, Chetek soils 30 percent, and other soils make up the rest.

**Hibbing-Chetek Association, rolling (HCC).**—This association occurs in the Mille Lacs moraine area, which is west of Mille Lacs Lake and is one of the more highly morainic places in the county. Slopes in this area, for the most part, are short and rolling; a few are steep. Hibbing soils and Chetek soils each make up 40 percent of the

association. Other soils make up the remaining 20 percent.

**Hibbing-Zim Association, nearly level (HZA).**—This association is not extensive. Hibbing soils make up about 30 percent of the association, Zim soils 40 percent, and Trommald soils 20 percent. Peat, moderately shallow over clays, and other soils make up the rest. The slope range is 2 to 4 percent.

**Hubbard Association, nearly level (HDA).**—This association consists of dark-colored, droughty, prairie soils. It adjoins the Mississippi River in an area southwest of Brainerd. The slope range is 0 to 3 percent. Hubbard soils make up about 80 percent of the association, and other soils, which are somewhat poorly drained, make up the rest.

The soils in this association are not particularly good for agriculture. In midsummer they do not supply enough water for crops. Nevertheless, most of the acreage is cultivated. A very small part is used for the production of trees.

**Hubbard Association, undulating (HDB).**—This association occupies only a small area. The slope range is 2 to 10 percent, but slopes of 4 to 7 percent predominate. Wind erosion is a major hazard. Hubbard soils make up 80 to 85 percent of the association, and more poorly drained soils make up the rest.

**Iosco-Dean Lake Association (ID).**—This association occurs in the Lake Aitkin basin, northeast of Deerwood. It is of minor extent in the county. Iosco soils and Dean Lake soils each make up 40 percent of the association. Moderately shallow Peat and other soils make up the remaining 20 percent.

**Lake beaches (LB).**—Crow Wing County has a large number of lakes, many of which have sandy beaches. Some beach areas are large enough to be shown on a soil map. These were mapped in the soil survey as Lake beaches. They support some trees and are used as sites for lakeside cabins. They have no agricultural value.

**Lino-Peat Association (LP).**—This association is widespread on the more poorly drained, sandy outwash flats and river terraces. Lino soils make up about 40 percent of the area, Peat 30 percent, Isanti soils 20 percent, and various other soils make up the rest. The soils in this association are wet and must be drained if they are to be used for either crop or tree production.

**Marsh (MR).**—This land type is poorly drained. Some areas are covered with shallow water most of the time. The vegetation is luxuriant and consists of sedges, reeds, and lowland brush. Marsh has no agricultural value. It is best used as a wildlife habitat.

**Menahga-Croswell Association, nearly level (MCA).**—Menahga soils make up approximately 50 percent of this association, and Croswell soils approximately 40 percent. These are the better drained, sandy soils in the Lake Aitkin basin, which is northeast of Deerwood. Soils that are somewhat poorly drained make up the remaining 10 percent of the association. Most of the area is used for the production of timber; jack pine is the dominant species. Wind erosion would be a hazard if the area were used for agriculture.

**Menahga-Nymore Association, nearly level (MNA).**—This is one of the most widespread associations in Crow Wing County. In some places, it consists almost entirely of Menahga soils, which cover broad areas in the county.



In others, it is about 70 percent Menahga soils, 20 percent Nymore soils, and 10 percent various poorly drained soils. The slope range is 0 to 3 percent, but slopes of 1 percent or 2 percent predominate.

Jack pine makes up the natural vegetation, and most of the acreage is used to produce jack pine for pulpwood. Only a very small part is cultivated, because the soils, being droughty and low in fertility, are not good for agriculture.

**Menahga-Nymore Association, undulating (MN8).**—This association is not as extensive as Menahga-Nymore Association, nearly level, but it does cover a sizable area. Menahga soils make up about 70 percent of the area, Nymore soils 20 percent, and poorly drained soils make up the rest. The slope range is 2 to 8 percent. Use, problems, and management are the same as for Menahga-Nymore Association, nearly level.

**Menahga-Nymore Association, rolling (MNC).**—This association is 70 to 75 percent Menahga soils and 5 to 10 percent Nymore soils. The rest consists of wetter soils in slight depressions, including Isanti soils and Peat. The slope range is 7 to more than 20 percent.

Little of the acreage has been cleared. Most of it is used to produce jack pine for pulpwood. The soils in this association are about as productive of jack pine as the nearly level phases of Menahga and Nymore soils. Because the soils are highly permeable, surface runoff is at a minimum, and thus their available moisture capacity is about the same as that of the nearly level phases.

**Nisswa-Merrifield Association (NM).**—This association occurs principally in the vicinity of Lake Edward, north of Brainerd. It is 60 percent Nisswa soils, 30 percent Merrifield soils, and about 10 percent miscellaneous soils, including Isanti soils and Peat, that are more poorly drained than Nisswa and Merrifield soils.

The soils in this association have fine-textured layers that slow the movement of water; consequently, they hold more moisture than Menahga and Nymore soils and support a different kind of vegetation. The vegetation is mostly hardwoods, including oak and aspen, and there is some white pine.

Nisswa and Merrifield soils are moderately good for agriculture. They are not stony, and they are less susceptible to wind erosion than many other sandy soils. Some areas have been cleared and are used for crops.

**Nokay-Brainerd Association, nearly level (NBA).**—This association occupies the lower lying slopes in drumlin fields. The slope range is 1 to 5 percent. Nokay soils make up about 50 percent of the association, Brainerd soils 30 percent, and some poorly drained and very poorly drained soils make up the rest. The soils in this association are moderately stony to extremely stony. Before they can be put to agricultural use, they must be cleared of stones.

**Nokay-Peat Association (NP).**—This association occupies the larger wetlands in the glacial till region. It consists mostly of soils in low-lying draws and swamps between drumlins. Nokay soils make up approximately 20 percent of the association, Barrows soils 40 percent, Peat 30 percent, and various other wet soils make up the rest.

The soils in this association are ponded much of the time, and water removal is necessary if they are to be used for hay or pasture.

**Nokay-Warman-Peat Association (NW).**—This association occupies the wetter areas within the Brainerd-Chetek Associations. It consists mostly of soils in low-lying draws and swamps between drumlins. Nokay soils make up 30 percent of the association, Warman soils 20 percent, Barrows soils 30 percent, and Peat makes up the rest.

The soils in this association are moderately stony to very stony and would have to be cleared of stones before being used for agriculture. Most areas support willows, alder, and some sedges and cattails. In dry years some wild hay is harvested.

**Peat (P).**—Peat consists of partly decomposed plant remains. Most of the peat in Crow Wing County occurs in open wet bogs and is made up of sedges. A smaller amount is made up of woody plants, and a very small amount is made up of sphagnum moss. Very few areas of Peat are used for agriculture or forestry. Most areas are of use only as wildlife habitats.

**Trommald-Peat Association (TP).**—This association occupies the wetlands within the Hibbing Association and the Hibbing-Zim Association. It is not extensive. Trommald soils make up about 70 percent of the area, Peat about 20 percent, and other soils make up the rest.

This association supports willows, alders, some black ash trees, and various sedges. It is not normally used for agriculture, since the soils are wet and would have to be drained. In some of the drier years, however, wild hay is harvested. This association is best suited to use as wildlife areas.

**Warman-Halder-Peat Association (WHP).**—This association occurs in depressions, or swales, within the Chetek-Onamia Association. Warman soils, Halder soils, and Peat each make up 30 percent of the association. Miscellaneous soils make up the remaining 10 percent.

The soils in this association are wetter than the surrounding Chetek and Onamia soils. Like other wet soils, they are used for wild hay in the drier years. If drained, these soils could be used for pasture and, in places, for crops. Normally they are not good producers of the trees commonly found in the county. They are best suited to use as wildlife areas.

## *Use, Management, and Productivity of the Soils*

This section consists of three main parts. The first is a guide to the use and management of the soils for agriculture; the second discusses the use of the soils for woodland; and the third part explains properties of the soils that affect engineering.

## **Use and Management of the Soils for Agriculture**

Basic management for cultivated fields and for pastures is discussed in the pages that follow. Also, the capability classification system is explained, and use and management of the soils in the county are discussed, by management groups. Next, a table gives, for each soil, expectable yields of crops and pasture under two levels of management.



### ***Basic management for cultivated areas***

In all cultivated areas, certain management practices are necessary to ensure good yields and at the same time conserve the soil. A primary requirement is proper cultivation that aerates the soil, improves tilth, conserves moisture by controlling weed growth, and partially incorporates manure and crop residues into the soil. In the pages that follow, other basic practices are discussed as they apply to the soils in Crow Wing County.

***Maintaining organic matter.***—Organic matter affects tilth and the chemistry of the soil. It (1) promotes soil aggregation and increases stability of the aggregates; (2) holds reserve supplies of plant nutrients; (3) increases resistance of the soil to erosion; (4) increases biological activity by providing the micro-organisms in the soil with food and energy; and (5) improves soil-water-plant relations by increasing the depth of arable soil and the volume of the soil-water reservoir.

The supply of organic matter can be maintained and, in many soils, increased by adding barnyard manure, turning under crop residues and green-manure crops, and using a rotation that includes 2 or more years of legumes or grasses.

***Rotating crops.***—A suitable crop rotation is an essential part of any management plan designed to maintain fertility and to conserve the soil. Proper rotation of crops (1) systematizes farming, (2) increases crop yields, (3) helps to maintain the supply of nitrogen and organic matter in the soil, (4) helps to control weeds, insects, and plant diseases, (5) keeps the soil covered a greater part of the time, and (6) saves labor and distributes it more efficiently.

The soil-depleting crops grown in Crow Wing County are corn, soybeans for grain, and small grains. Continued use of the soils for these crops causes the soil structure to deteriorate and tends to decrease the content of plant nutrients. The soil-building crops are legumes and grasses grown for hay and pasture. The proportion of row crops to legumes and grasses is the most important consideration in planning a crop rotation. The balance between the two determines the fertility level of the soil and the extent to which erosion is controlled.

***Liming acid soils.***—Most of the cropland in Crow Wing County is too acid for the satisfactory growth of certain crops, including alfalfa and clover. Generally, if good yields are to be obtained, the soils must be neutralized with lime. Tests should be made beforehand to determine the actual need, because the degree of acidity varies. The amount of lime needed to obtain the desired results depends upon the following factors: (1) Crops to be grown, (2) reaction of the soil, (3) texture, and (4) depth to the lime-containing subsoil.

Sandy soils can be neutralized with rather light applications of lime. Heavier applications are needed to neutralize silt loams, and still heavier applications to neutralize silty clay loams and clays. Heavy applications are also needed for peat and other organic soils. Ground limestone is usually the most economical form of lime to use.

***Adding commercial fertilizers.***—Plant nutrients are constantly being used by crops and removed from the soils by erosion and leaching. Nitrogen, phosphorus, potassium, and the other elements essential to plant growth must be replaced, especially in those soils that are nat-

urally low in these elements. A deficiency of one or more nutrients may seriously limit plant growth. Adding the needed nutrient or nutrients to the soil, in the form of commercial fertilizer or manure, will usually result in healthier, higher yielding, and earlier maturing plants.

Sandy soils are generally deficient in organic matter, nitrogen, and potassium. Those sandy soils planted to row crops will produce more if commercial fertilizers that contain nitrogen and potassium are applied. Soils used for hay and pasture respond well to applications of phosphorus. Even fertile soils may need an occasional application of some commercial fertilizer.

The Minnesota Agricultural Experiment Station and the county agricultural agent can supply more specific information about the fertilizer and lime requirements of the soils in Crow Wing County.

***Controlling erosion.***—Erosion control and water conservation practices are needed in Crow Wing County to keep losses of soil and water to a minimum. Practices that help to maintain or increase soil productivity also help to conserve soil and water. Tilling on the contour, for example, conserves soil and water and generally increases yields. Terracing, stripcropping, and sodding waterways usually help to control erosion. Keeping the soils under a plant cover and leaving crop residues on the surface help to check blowing of sandy soils. Rough tillage also checks soil blowing. Windbreaks are useful for protection of the areas most exposed to the wind.

Stripcropping is one of the most common practices used in this county to control sheet erosion. Contour stripcropping and a crop rotation that includes 2 to 4 years of hay are probably the best erosion control measures in cultivated fields. Contour strips are effective on slopes that are not too steep. The width of the strips must be decided with reference to slope, texture, tilth, degree of erosion, and crops in the rotation.

Terraces also provide permanent protection against erosion in cultivated fields. They are particularly useful for breaking up long gentle slopes that are intensively cropped. A whole field can be planted to one crop if terraced. Terracing provides better erosion control than stripcropping, and in some areas the two are combined with good results. The width of a strip may be the width of one or more terrace intervals.

Grassed waterways to carry off surplus water are a necessary part of a system of contour tillage, stripcropping, and terracing. They are best established by seeding the entire drainage area to meadow.

Crop rotations that include 2 years or more of hay are also important in controlling erosion. Short rotations (2 to 3 years) are adequate on gentle slopes. On steeper slopes, rotations lasting 4, 5, or even 6 years are more beneficial. Soil losses are low when the surface is protected with a close-growing crop. When a clean-cultivated crop is grown, losses are less if a hay or a pasture crop has been plowed under before the crop is planted.

### ***Basic management for pastures***

Pastures are an important part of any well-planned system of farm management. They provide forage for cattle, protect the soils from erosion, and produce large amounts of organic matter when plowed under. Ordinarily, three kinds of pasture—permanent, rotation, and supplementary—are needed to provide forage the year

round. Of these, a rotation pasture that is a mixture of grasses and legumes generally produces the most forage.

Permanent pastures should, so far as possible, be established on soils that are too stony, too steep, or too wet to be suitable for cultivated crops.

Rotation pastures generally yield more forage than permanent pastures because they are on better soils and receive barnyard manure. A legume-grass mixture makes a better pasture than a legume alone or a grass alone. A mixture of alfalfa and timothy or of alfalfa and brome-grass is best. Such a mixture provides pastures of good quality and yields about twice as much forage as unimproved permanent pastures. Good agricultural soils ordinarily are used part of the time for rotation pasture, supplementary pasture, or both.

Supplementary pastures produce forage during periods when permanent or rotation pastures do not provide enough. Winter rye, sudangrass, and spring-sown small grain are commonly used. Second-crop alfalfa can be used during July and August.

Many pastures in the county are poor because of overgrazing, sheet and gully erosion, lowered fertility, weeds, and brush. These pastures should be improved to increase yields and to protect the soils against erosion. Permanent pastures can be greatly improved by shifting livestock from one pasture to another so that pasture plants have time to recover after being grazed, by clipping weeds, by destroying brush, and by harrowing to spread droppings.

Fertility can be maintained or increased by applying lime and commercial fertilizers when the pastures are reseeded. Manure can be used alone or as a supplement to commercial fertilizers.

The establishment and maintenance of good plant cover is the best conservation measure. On some badly eroded and gullied sites, however, contour furrows, contour tillage, pasture terraces, and other supporting practices may be advisable.

### **Management groups of soils**

The capability classification is a grouping that shows, in a general way, how suitable soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit or management group. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, II*e*. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil interferes with plant growth or cultivation (in some soils wetness can be partly corrected by artificial drainage); *s* shows that the

soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

Class I has no subclasses, because the soils in this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no erosion hazard but have other limitations that limit their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the management groups. The soils in each group are enough alike to require similar management.

Soils are placed in capability classes, subclasses, and management groups according to the degree and kind of their permanent limitations, but without considering possible but unlikely reclamation projects, or major and generally expensive landforming that would change slope, depth, or other characteristics of the soil.

The eight classes in the capability system, and the subclasses and management groups in the part of the county covered by the detailed soil survey, are described in the list that follows. Immediately after the list, each of the management groups is discussed, the soils in each are listed, and practices for the group are suggested.

Class I. Soils that have few limitations that restrict their use. (Crow Wing County has no class I soils.)

Class II. Soils that have some limitations that reduce the choice of plants or that require moderate conservation practices.

Subclass II*e*. Soils subject to moderate erosion if they are not protected.

Management group 1.—Nearly level to gently sloping soils that developed from compacted, noncalcareous, stony, sandy loam till.

Management group 2.—Undulating, moderately well drained and well drained soils that developed from slightly calcareous, clayey glacial till.

Subclass II*w*. Soils moderately limited by excess water.

Management group 3.—Nearly level to undulating, somewhat poorly drained soils.

Class III. Soils that have severe limitations that reduce the choice of plants, or that require special conservation practices, or both.

Subclass III*e*. Soils subject to severe erosion if they are cultivated and not protected.

Management group 4.—Sloping and rolling soils that developed from compacted, noncalcareous, stony, sandy loam till with small spots of gravelly outwash.

Management group 5.—Gently sloping, moderately coarse textured soils over noncalcareous gravel.

Management group 6.—Rolling, light-colored soils that developed from slightly calcareous, clayey glacial till.

Subclass III*s*. Soils that have severe limitations of moisture capacity.

Management group 7.—Nearly level, moderately coarse textured, droughty soils over noncalcareous gravel.



Management group 8.—Nearly level to undulating, droughty loamy sands over noncalcareous, sandy loam glacial till.

Subclass IIIw. Soils that have severe limitations because of excess water.

Management group 9.—Nearly level, somewhat poorly drained soils.

Management group 10.—Nearly level, somewhat poorly drained soils that are not easily drained by artificial means.

Class IV. Soils that have very severe limitations that restrict the choice of plants, or that require very careful management, or both.

Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.

Management group 11.—Gently rolling to rolling, moderately droughty soils.

Subclass IVe. Soils very severely limited by low moisture-holding capacity.

Management group 12.—Nearly level to undulating, excessively drained, sandy soils.

Subclass IVw. Soils very severely limited by excess water.

Management group 13.—Nearly level or depressed, poorly drained or very poorly drained soils.

Management group 14.—Deep peat and moderately shallow peat over clay.

Class V. Soils that are not likely to erode but that have other limitations, impractical to remove, that restrict their use largely to pasture, woodland, or food and cover for wildlife.

Subclass Vw. Soils too wet for cultivation; drainage or protection not feasible.

Management group 15.—Alluvial land and moderately shallow peat over sands.

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and that restrict their use largely to pasture, range, woodland, or wildlife.

Subclass VIe. Soils severely limited, chiefly by risk of erosion, if protective cover is not maintained.

Management group 16.—Rolling, moderately well drained to excessively drained soils.

Subclass VIe. Soils generally unsuitable for cultivation and severely limited for other uses by drought.

Management group 17.—Rolling, excessively drained soils.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation without major reclamation, and that restrict their use largely to grazing, woodland, or wildlife.

Subclass VIIe. Soils very severely limited, chiefly by risk of erosion if protective cover is not maintained.

Management group 18.—Strongly rolling to steep, excessively drained soils.

Class VIII. Soils and landforms that have no agricultural value because of limitations that restrict their use to recreation, wildlife, water supply, or esthetic purposes.

Subclass VIIIw. Extremely wet soils or marshy land.

Management group 19.—Marsh.

#### MANAGEMENT GROUP 1 (CAPABILITY SUBCLASS IIe)

This group consists of nearly level to gently sloping, light-colored soils that developed from compacted, noncalcareous, stony, sandy loam till. These soils are stony in many places. The soils are—

Brainerd sandy loam, 0 to 2 percent slopes.

Brainerd sandy loam, 2 to 7 percent slopes.

These are moderately well drained soils. They have a very firm, somewhat cemented subsoil, which slows the movement of water, air, and roots.

These soils are low in organic-matter content. Normally, they respond to fertilizers containing nitrogen, phosphorus, and potash.

Many areas of these soils are in second-growth trees, mainly aspen, but other areas are farmed. Some corn is grown, along with small grain and hay. A suitable rotation consists of a row crop for 1 year, a small grain for 1 year, and hay or pasture for 2 years. Fertilizer and lime should be applied in amounts indicated by soil tests. Terracing and contour cultivation will help conserve moisture. Stone removal is a major management problem.

#### MANAGEMENT GROUP 2 (CAPABILITY SUBCLASS IIe)

Hibbing silt loam, 2 to 7 percent slopes, is the only soil in this management group. It is an undulating soil that developed from red, slightly calcareous, clayey glacial till. It is moderately well drained and well drained. The clayey till somewhat restricts the movement of moisture. The organic-matter content is low.

Many areas are in second-growth trees, mainly aspen, but other areas are farmed. Some corn can be grown, along with small grain and legume hay. A suitable rotation consists of corn for 1 year, a small grain for 1 year, and hay or pasture for 2 years. Lime and fertilizer should be applied in amounts indicated by soil tests. Contour strip cropping is needed on the stronger slopes. Because of relatively slow infiltration, erosion is a hazard. Increasing the organic-matter content would help to increase the rate of infiltration.

#### MANAGEMENT GROUP 3 (CAPABILITY SUBCLASS IIw)

The soils in this group are light colored, nearly level to undulating, and somewhat poorly drained. Almost every year they are wet during certain periods. The soils are—

Halder loam.

Nokay sandy loam, 0 to 2 percent slopes.

Nokay sandy loam, 2 to 7 percent slopes.

Halder loam is underlain by gravel at a depth of 24 to 36 inches. The sandy loam of the Nokay soils grades into a slightly cemented, stony subsoil at a depth of 18 to 30 inches. Seep spots are common in the Nokay soils.

These soils are used for growing the general farm crops commonly grown in the county. A suitable rotation consists of a row crop for 1 year, a small grain for 1 year, and hay or pasture for 2 years.

Excessive wetness is the major management problem. Needed are practices that will permit excess water to drain off without causing erosion.

#### MANAGEMENT GROUP 4 (CAPABILITY SUBCLASS IIIe)

Brainerd sandy loam, 7 to 13 percent slopes, is the only soil in this management group. It is a sloping and rolling, light-colored soil that developed mainly from com-

pacted, noncalcareous, stony, sandy loam till. It is moderately well drained.

This soil is of only minor extent in the county. Much of it supports second-growth trees. Only scattered areas are farmed. A suitable rotation consists of an intertilled crop for 1 year, a small grain for 1 year, and hay or pasture for 3 years. Fertilizer and lime should be applied in amounts indicated by soil tests. Contour stripcropping and contour tillage are needed in many places.

#### MANAGEMENT GROUP 5 (CAPABILITY SUBCLASS IIIe)

This group consists of gently sloping, moderately coarse textured soils that overlie noncalcareous gravel. The soils are—

- Brainerd-Chetek complex, 2 to 7 percent slopes.
- Burkhardt sandy loam, 2 to 7 percent slopes.
- Chetek sandy loam, 2 to 7 percent slopes.
- Onamia sandy loam, 2 to 7 percent slopes.

These soils, though somewhat droughty, are suited to most of the crops grown in the county. In forest areas, red pine grows well. A suitable rotation consists of an intertilled crop for 1 year, a small grain for 1 year, and hay for 2 years.

#### MANAGEMENT GROUP 6 (CAPABILITY SUBCLASS IIIe)

Hibbing silt loam, 7 to 13 percent slopes, is the only soil in this management group. It is a rolling, light-colored soil that developed from red, slightly calcareous, clayey glacial till.

Because of slow permeability, this soil is subject to severe erosion. Consequently, it is not usually cultivated. Many areas are in second-growth trees, mainly aspen, though the soil is well suited to hay and pasture. Crops respond well to commercial fertilizer, especially to nitrogen.

#### MANAGEMENT GROUP 7 (CAPABILITY SUBCLASS IIIs)

The soils in this group are nearly level, moderately coarse textured, and droughty. They overlie noncalcareous gravel. The soils are—

- Burkhardt sandy loam, 0 to 2 percent slopes.
- Chetek sandy loam, 0 to 2 percent slopes.
- Onamia sandy loam, 0 to 2 percent slopes.

These soils are widely used for crop production. A suitable rotation consists of corn for 1 year, a small grain for 1 year, and hay or pasture for 2 years. Erosion is not a serious problem, because the soils are nearly level.

#### MANAGEMENT GROUP 8 (CAPABILITY SUBCLASS IIIs)

This group consists of nearly level to undulating, light-colored, droughty loamy sands that are underlain, at a depth of 24 to 42 inches, by stony, noncalcareous, slightly cemented, sandy loam glacial till. The soils are—

- Pomroy loamy sand, 0 to 2 percent slopes.
- Pomroy loamy sand, 2 to 7 percent slopes.

These are well-drained soils. They are suited to the crops commonly grown in the area. A suitable rotation consists of a row crop for 1 year, a small grain for 1 year, and hay or pasture for 2 years. Fertilizer and lime should be applied in amounts indicated by soil tests. Terracing and contour stripcropping are needed in the undulating areas. Wind erosion is a problem, and protection against the wind should be provided for as much of the year as possible, but droughtiness is the major management problem. The underlying glacial till, how-

ever, slows the movement of water to the extent that these soils are less droughty than the deep sands in group 12.

#### MANAGEMENT GROUP 9 (CAPABILITY SUBCLASS IIIw)

The soils in this group are nearly level, moderately dark colored, and somewhat poorly drained. They are—

- Iosco loamy sand, shallow.
- Lino loamy sand.
- Watab loamy sand.

The loamy sand of the Lino soil grades to sand at a depth of 24 to 36 inches. Watab loamy sand is underlain by noncalcareous, stony, sandy loam glacial till at a depth of 24 to 42 inches.

The soils in this group are wet but not too wet to be cultivated. They are suited to the general farm crops grown in the area. A suitable rotation consists of a row crop for 1 year, a small grain for 1 year, and hay or pasture for 2 years. Crops respond well to fertilizer. Fertilizer and lime should be applied in amounts indicated by soil tests.

#### MANAGEMENT GROUP 10 (CAPABILITY SUBCLASS IIIw)

Zim silty clay loam is the only soil in this management group. It is a nearly level, light-colored soil that developed from red, slightly calcareous, clayey glacial till.

This soil is somewhat poorly drained and does not lend itself to artificial drainage. In some years the excessive wetness prevents a good growth of small grain. The soil is well suited to hay and pasture. Crops respond well to commercial fertilizer, especially to nitrogen.

#### MANAGEMENT GROUP 11 (CAPABILITY SUBCLASS IVe)

The soils in this management group are gently rolling to rolling, light colored, and moderately droughty. In some places the slopes are relatively uniform, but in others they are complex. The soils are—

- Brainerd-Chetek complex, 7 to 13 percent slopes.
- Chetek sandy loam, 7 to 13 percent slopes.
- Onamia sandy loam, 7 to 13 percent slopes.
- Pomroy loamy sand, 7 to 13 percent slopes.

Onamia sandy loam is underlain by noncalcareous gravel or sandy gravel at a depth of 24 to 36 inches. Pomroy loamy sand is underlain by slightly cemented, sandy loam till at a depth of 24 to 42 inches.

The soils in this group are low in organic-matter content. They are highly susceptible to erosion. A suitable rotation consists of a small grain for 1 year and hay or pasture for 2 or 3 years. Lime and fertilizer should be applied in amounts indicated by soil tests.

#### MANAGEMENT GROUP 12 (CAPABILITY SUBCLASS IVs)

This group consists of nearly level to undulating, excessively drained, sandy soils. These soils are—

- Chetek gravelly loamy sand, 0 to 2 percent slopes.
- Hubbard loamy sand, 0 to 2 percent slopes.
- Hubbard loamy sand, 0 to 2 percent slopes, moderately wind eroded.
- Hubbard loamy sand, 2 to 7 percent slopes.
- Lake beaches.
- Menahga loamy sand and sand, 0 to 2 percent slopes.
- Menahga loamy sand and sand, 2 to 7 percent slopes.
- Nymore loamy sand, 0 to 2 percent slopes.
- Nymore loamy sand, 2 to 7 percent slopes.

The surface layer of the Hubbard soils is dark colored; it grades to sand at a depth of 24 to 30 inches. The sur-



face layer of the Menahga soils is light colored, and that of the Nymore soils is moderately dark colored. The Menahga and Nymore soils have sand at a depth of 18 to 24 inches.

Most areas of the soils in this group are used for production of trees. Some are used for pasture, and other small areas are used for cultivated crops. Pasture and crop yields are low because of droughtiness, which is the major limitation. Cultivated crops should not be grown without irrigation. Wind erosion is a hazard in areas that are farmed.

#### MANAGEMENT GROUP 13 (CAPABILITY SUBCLASS IV<sub>w</sub>)

This group consists of soils that are nearly level or depressed, poorly drained or very poorly drained, and moderately dark colored or dark colored. The soils are—

Barrows loam and sandy loam.  
Isanti sandy loam.  
Nokasippi sandy loam.  
Warman loam.

Most areas of these soils are too wet for the common cultivated crops. They are used mainly for hay or pasture. Drainage likely would improve these soils, but it is not economically feasible. Pasture crops normally respond to fertilizer, especially to nitrogen. For best results, fertilizer should be applied in amounts indicated by soil tests.

#### MANAGEMENT GROUP 14 (CAPABILITY SUBCLASS IV<sub>w</sub>)

This group consists of moderately shallow and deep organic soils that overlie clay. The soils are—

Peat, deep.  
Peat, moderately shallow over clays.

If these soils were drained, they could be used for agricultural and horticultural crops, but few areas are drained. Some scattered areas are used for hay and pasture, but most are used as wildlife habitats. Frost would be a major hazard to crops on these soils.

#### MANAGEMENT GROUP 15 (CAPABILITY SUBCLASS V<sub>w</sub>)

This group consists of wet to excessively wet soils. The soils are—

Alluvial land.  
Peat, moderately shallow over sands.

Drainage is not feasible in areas of Peat, because it would be difficult to establish ditchbanks in the sandy substratum. Alluvial land is subject to flooding. These soils are used mostly as wildlife habitats. Some areas are in hay and pasture.

#### MANAGEMENT GROUP 16 (CAPABILITY SUBCLASS VI<sub>e</sub>)

This group consists of rolling, light-colored and dark-colored, moderately well drained to excessively drained soils. The soils are—

Chetek sandy loam, 13 to 18 percent slopes.  
Pomroy loamy sand, 13 to 18 percent slopes.

These droughty soils are not suitable for crops, and they produce only small amounts of grass if used for pasture. They are best suited to the production of jack pine and red pine. A permanent cover of trees provides protection against wind and water erosion.

#### MANAGEMENT GROUP 17 (CAPABILITY SUBCLASS VI<sub>s</sub>)

The soils in this group are rolling, light colored and dark colored, and excessively drained. They are—

Hubbard loamy sand, 7 to 13 percent slopes.  
Menahga loamy sand and sand, 7 to 13 percent slopes.  
Nymore loamy sand, 7 to 13 percent slopes.

These soils are too droughty and too strongly sloping for cultivation. To some extent they can be used as permanent pasture, but they are best suited to production of jack pine and red pine.

#### MANAGEMENT GROUP 18 (CAPABILITY SUBCLASS VII<sub>e</sub>)

Chetek sandy loam, 18 to 30 percent slopes, is the only soil in this management group. It is a strongly rolling to steep, light-colored, excessively drained soil. Because of the strong slopes, it is highly susceptible to erosion. It is also droughty. This soil is best used for production of jack pine and red pine.

#### MANAGEMENT GROUP 19 (CAPABILITY SUBCLASS VIII<sub>w</sub>)

Marsh, a miscellaneous land type, makes up this management group. It occurs in depressions and is wet or covered with water throughout the year. It is not suited to either agriculture or forestry. Marsh is best used as a habitat for wildlife, especially for wetland animals and birds.

### Expectable yields

Table 3 gives expectable average acre yields of some of the crops commonly grown in the county. In the A columns are yields to be expected under customary management, and in the B columns are yields to be expected under improved management.

## Use of the Soils for Woodland

A large part of the acreage in Crow Wing County is used for tree production. At present only three important commercial species of trees grow in the county. These are jack pine (*Pinus banksiana*), bigtooth aspen (*Populus grandidentata*), and quaking aspen (*Populus tremuloides*). For the purposes of this report, the two species of aspen are grouped together. Other species, including red pine (*Pinus resinosa*) are white spruce (*Picea glauca*), grow on certain soils in the county.

Brush, mainly hazel (*Corylus*), alder (*Alnus*), and willow (*Salix*), is abundant in wooded areas. It established itself after the larger trees had been removed. Some cut-over areas where the vegetation consists of young trees seem, from a distance or at first glance, to be covered with brush.

### Woodland suitability groups of soils

To assist owners in planning the proper use and management of their woodlands, the soil series in the county have been placed in 11 woodland suitability groups. Since slope has little or no effect on tree production in this county, these groups were set up by soil series instead of by mapping units. (Soils in the Chetek series, however, were placed in two groups on the basis of texture.) Thus, the interpretations can be applied, in a general way, to the area covered by the reconnaissance survey, as well as to that covered by the detailed survey. Each woodland suitability group consists of soils that are about the same in productivity of trees and that have soil-related limitations requiring about the same woodland management. These groups are listed in table 4 and discussed in pages that follow.

TABLE 3.—*Expectable average acre yields of common crops and carrying capacity of pasture*

[Yields in A columns are to be expected under customary management; those in B columns, under improved management. Absence of yield in a column indicates that the crop is not commonly grown or that yields would be too low or that management needs are too exacting to warrant growing the crop]

Map symbol	Soil	Corn (grain)		Oats		Mixed hay		Corn (silage)		Pasture (rotation)	
		A	B	A	B	A	B	A	B	A	B
		Bu. 25	Bu. 30	Bu. 25	Bu. 30	Tons 0.8	Tons 1.1	Tons 6	Tons 7	Cow-days <sup>1</sup> 40	Cow-days <sup>1</sup> 60
Ad	Alluvial land (drained).....										
Ba	Barrows loam and sandy loam (drained).....			30	45	1.2	1.8			60	100
BbA	Brainerd sandy loam, 0 to 2 percent slopes.....	45	55	40	60	1.8	2.5	10	12	100	130
BbB	Brainerd sandy loam, 2 to 7 percent slopes.....	40	50	40	55	1.8	2.5	10	11	90	125
BbC	Brainerd sandy loam, 7 to 13 percent slopes.....	35	45	30	50	1.4	2.3	8	10	80	115
BcB	Brainerd-Chetek complex, 2 to 7 percent slopes.....	30	35	25	45	1.0	2.0	8	9	60	105
BcC	Brainerd-Chetek complex, 7 to 13 percent slopes.....			25	40	1.0	1.9			55	100
BuA	Burkhardt sandy loam, 0 to 2 percent slopes.....	35	45	30	45	1.2	2.0	8	10	65	100
BuB	Burkhardt sandy loam, 2 to 7 percent slopes.....	30	40	25	40	1.1	1.7	7	9	60	85
CgA	Chetek gravelly loamy sand, 0 to 2 percent slopes.....										
ChA	Chetek sandy loam, 0 to 2 percent slopes.....	30	40	30	40	1.3	1.8	7	9	70	85
ChB	Chetek sandy loam, 2 to 7 percent slopes.....	25	35	25	40	1.1	1.7	6	8	60	80
ChC	Chetek sandy loam, 7 to 13 percent slopes.....			20	30	.8	1.4			40	75
ChD	Chetek sandy loam, 13 to 18 percent slopes.....					.7	1.0			40	60
ChE	Chetek sandy loam, 18 to 30 percent slopes.....										
Ha	Halder loam.....	40	50	40	55	1.7	2.5	9	11	85	130
HbB	Hibbing silt loam, 2 to 7 percent slopes.....	45	55	40	45	1.8	2.5	10	12	100	130
HbC	Hibbing silt loam, 7 to 13 percent slopes.....	30	40	35	40	1.5	2.3	9	10	90	110
HuA	Hubbard loamy sand, 0 to 2 percent slopes.....	25	35	25	35	1.0	1.5	6	8	55	80
HuA2	Hubbard loamy sand, 0 to 2 percent slopes, moderately wind eroded.....										
HuB	Hubbard loamy sand, 2 to 7 percent slopes.....			20	30	.9	1.4			50	75
HuC	Hubbard loamy sand, 7 to 13 percent slopes.....			20	30	.9	1.3			45	70
Io	Iosco loamy sand, shallow.....	30	35	35	45	1.4	2.2	8	10	70	85
Is	Isanti sandy loam (drained).....	25	30	20	35		1.5	6	7	60	80
Lb	Lake beaches.....										
Lo	Lino loamy sand.....	30	35	30	40	1.0	1.5	7	8	60	75
MaA	Menahga loamy sand and sand, 0 to 2 percent slopes.....			30	40	1.0	1.5			55	70
MaB	Menahga loamy sand and sand, 2 to 7 percent slopes.....									50	65
MaC	Menahga loamy sand and sand, 7 to 13 percent slopes.....									45	60
Mr	Marsh.....										
Nk	Nokasippi sandy loam (drained).....			30	40	1.2	1.7			65	85
NoA	Nokay sandy loam, 0 to 2 percent slopes.....	40	50	40	55	1.8	2.5	10	12	90	130
NoB	Nokay sandy loam, 2 to 7 percent slopes.....	35	45	35	55	1.6	2.5	9	11	85	125
NyA	Nymore loamy sand, 0 to 2 percent slopes.....			30	40	1.0	1.4			60	90
NyB	Nymore loamy sand, 2 to 7 percent slopes.....									55	85
NyC	Nymore loamy sand, 7 to 13 percent slopes.....									50	75
OnA	Onamia sandy loam, 0 to 2 percent slopes.....	45	55	40	60	1.9	2.5	10	12	90	130
OnB	Onamia sandy loam, 2 to 7 percent slopes.....	35	45	35	50	1.6	2.3	8	10	85	120
OnC	Onamia sandy loam, 7 to 13 percent slopes.....			30	45	1.2	2.0			65	110
Pa	Peat, deep.....			40	45	1.7	2.1	8	10	90	125
Pc	Peat, moderately shallow over clays.....	35	40	35	45	1.7	2.1	8	10	90	130
Pg	Peat, moderately shallow over sands.....										
PoA	Pomroy loamy sand, 0 to 2 percent slopes.....			35	45	1.2	1.6			65	85
PoB	Pomroy loamy sand, 2 to 7 percent slopes.....			30	40	1.0	1.4			55	75
PoC	Pomroy loamy sand, 7 to 13 percent slopes.....									45	65
PoD	Pomroy loamy sand, 13 to 18 percent slopes.....									40	60
Wa	Warman loam (drained).....	40	55	40	55	1.4	2.1	10	12	75	125
Wt	Watab loamy sand.....	35	40	35	45	1.3	1.6	8	10	70	85
Zc	Zim silty clay loam.....	30	35	35	50	1.6	2.4	8	10	80	115

<sup>1</sup> Number of days a year that 1 acre of pasture will graze 1 cow without injury to the pasture.



Table 4 also gives, in summary form, the estimated productivity (expressed as site index) of jack pine and aspen for each of the groups. Other species, notably red pine and white spruce, do not grow in sufficient quantity in the county to make growth predictions possible. Red pine, however, would probably grow at about the same rate as jack pine, and white spruce at about the same rate as aspen.

The relative severity of some of the soil-related hazards and limitations to be considered in woodland management is also given in table 4. These limitations, and soil productivity for wood crops, are explained in the following paragraphs.

Productivity, a measure of the amount of a given wood crop that a given soil can produce under a specified level of management, can be estimated from the site index. Site index is the average height, in feet, that trees of a given species, growing on a specified soil, will reach in 50 years. In table 4 an average figure and a range are given for each group of soils. For example, a site index of  $56 \pm 4$  means that the trees will average 56 feet in height at 50 years of age on the soils of the particular group, and that two samples out of three will not vary more than 4 feet from this average.

A site where an opening has been made in the canopy may be invaded by undesirable trees, brush, shrubs, or other plants. The invading plants compete with the desirable trees and hinder their reestablishment and growth. Plant competition is rated as follows:

**Slight.**—No problem is apparent. Undesirable species will not impede natural regeneration and growth of desirable species.

**Moderate.**—Competition generally will not impede establishment of desirable species. Development of a normal, fully stocked stand may take longer because establishment may be delayed and normal growth slowed. Simple management practices may be needed to minimize the competition.

**Severe.**—Competition is so severe that natural regeneration cannot be relied upon to provide adequate restocking of desirable species. Site preparation and special management practices, such as controlled burning, spraying with chemicals, shearing, or replanting are necessary.

Drainage, slope, soil texture, consistence, or other soil characteristics or topographic features may restrict or prohibit the use of equipment commonly used in woodland management and harvesting. Different soils may require different kinds of equipment, or special methods of operation, or may be unsuitable for machine use at different seasons. Equipment limitation is rated as follows:

**Slight.**—Little or no restriction on the type of equipment that can be used or the time of year that equipment can be used.

**Moderate.**—Not all kinds of equipment can be used, because of slope, stones, or other obstructions. Periods of extreme wetness or dryness may temporarily restrict use, but for not more than 3 months in the year.

**Severe.**—Equipment use is restricted for more than 3 months because of wetness or other unfavorable soil characteristics. Use of equipment could cause

damage to roots and serious damage to the structure and stability of the soil.

#### WOODLAND SUITABILITY GROUP 1

This group consists of those soils in the Chetek series that have sandy loam texture. These soils overlie non-calcareous sand or gravel at a depth of 18 to 24 inches.

Usually these soils support aspen or jack pine. In areas recently cutover, red oak has become established.

The site index for jack pine ranges from 47 to 57; the average is 52. For aspen, the site index ranges from 54 to 66, and the average is 60. The site indexes are highest in places where the depth to sand and gravel is greatest and where stands are fully stocked.

The only management problem is the invasion of understocked stands of jack pine by red oak, hazel brush, and other undesirable growth.

The equipment limitation is slight and exists only in a few scattered areas of stronger slope.

TABLE 4.—Woodland suitability groups, average site indexes, and ratings for plant competition and equipment limitation

[Absence of a site index indicates that the soils are not suited to the species]

Woodland suitability groups and soil series	Average site index		Plant competition	Equipment limitation
	Jack pine	Aspen		
Group 1: Chetek <sup>1</sup>	52 ± 5	60 ± 6	Moderate	Slight.
Group 2: Burkhardt, Onamia.	60 ± 5	71 ± 6	Moderate	Slight.
Group 3: Chetek, <sup>2</sup> Hubbard, Lake beaches, Menahga, Nymore.	49 ± 5	-----	Slight	Slight (loose sand in places).
Group 4: Pomroy	59 ± 4	60 ± 5	Slight	Slight.
Group 5: Brai-nerd.	-----	78 ± 5	Severe	Moderate (stony).
Group 6: Halder, Nokay.	-----	75 ± 4	Severe	Moderate (stony; wet in spring).
Group 7: Hibbing	-----	82 ± 4	Severe	Moderate (high clay content causes softness in spring).
Group 8: Zim	-----	78 ± 6	Severe	Moderate to severe (high clay content; wet at times).
Group 9: Alluvial land, Barrows, Isanti, Nokasippi, Warman.	-----	60 ± 8	Severe	Severe (high water table; very wet in spring, summer, and fall).
Group 10: Iosco, Lino, Watab.	58 ± 5	70 ± 6	Moderate to severe.	Slight (wet for short period in spring.)
Group 11: Peat, Marsh.	-----	-----	Severe	Severe (poor bearing strength during frost-free period).

<sup>1</sup> Sandy loam texture.

<sup>2</sup> Gravelly loamy sand texture.

**WOODLAND SUITABILITY GROUP 2**

This group consists of soils in the Burkhardt and Onamia series. These soils are nearly level or gently sloping and are moderately deep to gravel or sand. They have moderate water-holding capacity.

Aspen is the major species on these soils; jack pine grows in scattered areas. In areas recently cutover, aspen, red oak, and brush are found.

The site index for jack pine ranges from 55 to 65; the average is 60. For aspen, the site index ranges from 65 to 77, and the average is 71. The site indexes are highest where the silt and clay content of the solum is highest and the depth to the underlying gravel and sand is greatest.

Plant competition is moderate; brush competes with young trees.

There is no special equipment limitation.

**WOODLAND SUITABILITY GROUP 3**

This group consists of soils in the Hubbard, Menahga, and Nymore series, those soils in the Chetek series that have gravelly loamy sand texture, and Lake beaches.

Birch grows on some areas of Lake beaches. The rest of the soils support jack pine. A few areas have been planted to red pine with fair results. The soils are too droughty for aspen, though aspen is scattered among the pine. Some cutover areas have been invaded by a slow-growing red oak.

The site index for jack pine ranges from 44 to 54. The average site index is 49.

Plant competition is slight and is a problem only where stands are poorly stocked. Here, hazel brush and red oak may invade.

Loose sand limits the use of trucks and tractors in some places.

**WOODLAND SUITABILITY GROUP 4**

This group consists of soils in the Pomroy series. Pomroy soils closely resemble the soils in woodland group 3 in surface characteristics, but they have higher moisture-supplying capacity because underlying glacial till restricts the flow of water through the soil. Consequently, Pomroy soils support both aspen and jack pine, and site indexes are higher than for the soils in group 3.

The site index for jack pine ranges from 55 to 63; the average is 59. For aspen, the site index ranges from 55 to 65, and the average is 60.

Plant competition is slight. Shallow-rooting brush does not invade, because the low available moisture capacity in the upper layers of soil is not conducive to its growth.

There is no apparent equipment limitation.

**WOODLAND SUITABILITY GROUP 5**

The only soils in this group are those in the Brainerd series. They are moderately well drained and developed from compact glacial till. Aspen is the only important tree species.

The site index for aspen on Brainerd soils ranges from 73 to 83; the average site index is 78.

Plant competition is severe. Where aspen is cut for pulpwood and where stands are poorly stocked, hazel brush invades profusely.

The equipment limitation is moderate for about a month during spring when the ground is thawing. Some areas

are very stony, and the stones may be bothersome when using certain kinds of machinery.

**WOODLAND SUITABILITY GROUP 6**

This group consists of soils in the Halder and Nokay series. These soils are somewhat poorly drained. They are too wet for jack pine. Aspen is the only major species they support.

The site index for aspen ranges from 71 to 79; the average is 75.

Plant competition is severe. Hazel brush and, in places, alder and willow, grow in such abundance that trees have a difficult time establishing themselves.

The equipment limitation is moderate, for the soils are wet in spring and in fall, and some are very stony.

**WOODLAND SUITABILITY GROUP 7**

The only soils in this group are those in the Hibbing series. They are moderately well drained and developed from red or reddish-brown, slightly calcareous, clayey glacial till.

Aspen is widely distributed on these soils. Some white spruce is found but not enough to be harvested as a wood crop or to serve as a basis for a site index. Some maple and basswood trees occur in scattered areas. Jack pine does not grow on these soils, because the high moisture-supplying capacity results in severe plant competition.

The site index for aspen, which ranges from 78 to 86 and averages 82, is the highest in all the woodland groups.

Plant competition is severe. Where stands are understocked, hazel and alder brush grow profusely and hamper natural regeneration of trees.

The equipment limitation is moderate during the wet weather in spring and sometimes in fall, when the soils are soft because of their high clay content.

**WOODLAND SUITABILITY GROUP 8**

This group consists only of soils in the Zim series. Zim soils are the somewhat poorly drained associates of Hibbing soils, which are in group 7. They are not so productive as Hibbing soils, because of wetness.

Zim soils support aspen but not jack pine. Maple and basswood trees and other hardwoods occur as scattered stands in some areas but not in sufficient numbers to be harvested as a merchantable crop.

The site index for aspen ranges from 72 to 84; the average is 78.

Plant competition is severe, as in group 7, and the equipment limitation is greater than in group 7 because the soils in this group are wetter.

**WOODLAND SUITABILITY GROUP 9**

This group is made up of Alluvial land and of soils in the Barrows, Isanti, Nokasippi, and Warman series. All of these soils are poorly drained. The degree of wetness rather than soil properties determines the vegetation on these soils.

In many places the vegetation is mixed. Some stands of aspen are large enough and pure enough to serve as a basis for a site index. Other species, which grow in varying numbers, include elm, black ash, white spruce, and willow; species of brush include hazel and alder.

The site index for aspen ranges from 52 to 68; the average is 60.



The competition from brush is severe.

The equipment limitation is severe during frost-free periods when the soils are wet. Ordinary mechanized equipment can be used only during winter when the soils are frozen.

#### WOODLAND SUITABILITY GROUP 10

This group consists of soils in the Iosco, Lino, and Watab series. These soils are mostly somewhat poorly drained and sandy. Some have sand overlying finer textured material. On the better drained soils some jack pine is grown, but aspen is more common.

The site index for jack pine ranges from 53 to 63; the average is 58. The site index for aspen ranges from 64 to 76, and the average is 70.

Plant competition is moderate to severe. Hazel brush is the principal invader.

The equipment limitation is slight and exists only for short periods, usually in spring, when the soils are wet.

#### WOODLAND SUITABILITY GROUP 11

Peat and Marsh make up this group. They do not support trees in sizable numbers. In places they support some brush, including alder and willow.

## Engineering Applications

Some soil properties are of special interest to engineers because they affect construction and maintenance of roads, airports, pipelines, building foundations, structures for water storage, structures for controlling erosion, drainage systems, and sewage disposal systems. The soil properties most important to the engineer are permeability to water, shear strength, drainage, grain size, plasticity, and pH. Compaction characteristics, shrink-swell characteristics, depth to water table, depth to bedrock, and topography are perhaps almost as important.

The characteristics of the soils in Crow Wing County are described in detail in the section "Descriptions of the Soils." Those characteristics that are likely to affect engineering are summarized in this subsection for engineers and others concerned with use of the soils in construction.

Information in this subsection is useful in—

1. Selecting and developing sites for industry, businesses, homes, and recreation.
2. Selecting locations for highways, pipelines, and airports.
3. Determining the suitability of the soils for agricultural drainage systems, farm ponds, irrigation systems, and diversion terraces.
4. Locating sand and gravel for construction purposes.
5. Correlating pavement performance with kinds of soils and thus developing information that will aid in designing and maintaining pavements.
6. Determining whether or not vehicles and construction equipment can be moved over the soils.
7. Making maps and reports that can be used readily by engineers.

*The interpretations in this subsection are necessarily generalized and do not eliminate the need for sampling and testing the soil material in place at the proposed site*

*of a project; they should be used primarily in planning more detailed field investigations.*

Some terms used in this report have a special meaning to soil scientists and may be unfamiliar to engineers. These terms and others are defined in the Glossary at the back of this report.

The engineering data are presented in two tables. Table 5 provides data resulting from laboratory analysis of representative soils, and table 6 shows the suitability of the soils for various engineering uses.

### Engineering classification systems

The engineering classification systems now most widely used are the American Association of State Highway Officials (AASHTO) system<sup>1</sup> and the Unified system,<sup>2</sup> developed by the Corps of Engineers, U.S. Army. Both systems classify soil material according to gradation and plasticity characteristics.

The AASHTO system is used by most highway engineers. It places soil material in seven principal groups. The groups range from A-1, which consists of gravelly soils of high bearing capacity, to A-7, which consists of clayey soils that have low strength when wet. Table 5 shows these groups. Within each group the relative engineering value of the soil material is indicated by a group index number. The numbers range from 0 for the best material to 20 for the poorest. The next to last column of table 5 shows the group index numbers of the soils tested. The numbers are in parentheses following the AASHTO soil group symbol.

The Unified Soil Classification system is preferred by some engineers. This system classifies soil material as coarse grained (eight classes), fine grained (six classes), or highly organic (one class).

Table 5 shows both the AASHTO and the Unified classification of the soils tested.

### Soil test data

Samples of two types each of two soil series were tested to help evaluate the soils for engineering purposes. Table 5 gives the results. The test data show some variations in physical characteristics of soils in the same series, but they probably do not show the maximum variations that exist within the series sampled.

In the moisture-density (compaction) tests, soil material is compacted into a mold several times, each time at a successively higher moisture content, while the compactive effort remains constant. The dry density (unit weight) of the compacted material increases as the moisture content increases, until the optimum moisture content is reached. After that, the dry density decreases as the moisture content increases. The highest dry density obtained in the test is the maximum dry density, and the corresponding moisture content is optimum moisture. Moisture-density data are important in earthwork because, as a rule, optimum stability is obtained if the soil is com-

<sup>1</sup> AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Pt. 1, Ed. 8, illus., 1961. Designation: M 145-59—THE CLASSIFICATION OF SOILS AND SOIL AGGREGATE MIXTURES FOR HIGHWAY CONSTRUCTION PURPOSES.

<sup>2</sup> WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS. UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. No. 3-357, v. 1, 1953.

TABLE 5.—*Engineering*

[Tests performed by Bureau of Public Roads (BPR) in accordance with standard

Soil name and location of sample	Parent material	Bureau of Public Roads report No.	Depth	Horizon	Moisture-density data <sup>1</sup>	
					Maximum dry density	Optimum moisture
Brainerd sandy loam: NE. cor. of SE¼ sec. 28, T. 45 N., R. 30 W. (Modal).	Glacial till.	S33196 S33197 S33198	<i>Inches</i> 6 to 17 21 to 28 33 to 48	A22----- B2m----- C2m-----	<i>Lb. per cu. ft.</i> 127 133 131	<i>Percent</i> 9 8 8
NW¼ sec. 34, T. 45 N., R. 30 W. (Sandy variation).	Glacial till.	S33202 S33203 S33204	4 to 10 37 to 60 60+	A21----- Bm----- Cm-----	129 131 132	8 8 8
Brainerd loam: SW. cor. of NW¼ sec. 28, T. 44 N., R. 30 W. (Fine-textured variation).	Glacial till.	S33199 S33200 S33201	3 to 13 28 to 38 50 to 60	A2----- B2m----- Cm-----	124 130 134	10 9 8
Hibbing silt loam: NW. cor. sec. 34, T. 136 N., R. 26 W. (Modal, red clay till).	Glacial till.	S33205 S33206 S33207	0 to 8 16 to 33 42 to 64	A2----- B2----- C1-----	116 104 97	13 21 26
Center of sec. 36, T. 47 N., R. 25 W. (Brown clay till variation).	Glacial till.	S33208 S33209 S33210	2 to 7 9 to 20 40+	A2----- B2----- C2-----	111 103 108	15 20 18
Hibbing loam: SE. cor. sec. 30, T. 47 N., R. 25 W. (Coarse-textured variation).	Glacial till.	S33211 S33212 S33213	1 to 8 8 to 19 21+	A2----- B2----- C-----	121 107 116	10 17 15

<sup>1</sup> Based on AASHTO Designation: T 99-57, "The Moisture-Density Relations of Soils Using a 5.5-lb. Rammer and a 12-in. Drop," (Method A) in "Standard Specifications for Highway Materials and Methods of Sampling and Testing," pt. 2, Ed. 8 (1961), published by AASHTO.

<sup>2</sup> According to Designation: T 88-57, "Mechanical Analysis of Soils," in "Standard Specifications for Highway Materials and Methods of Sampling and Testing," pt. 2, Ed. 8 (1961), published by AASHTO. Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is

packed to about the maximum dry density at approximately optimum moisture.

The engineering soil classifications in table 5 are based on mechanical analysis and on tests that determine the liquid limit and the plastic limit of soils. The mechanical analysis was made by combined sieve and hydrometer methods. The results are useful in determining the relative proportions of the different sized particles. The percentages of clay obtained by the hydrometer method are not used for naming soil textural classes, since soil scientists determine percentages of clay by the pipette method.

The liquid limit and the plasticity index indicate the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases, the consistence changes from semisolid to plastic, and then from plastic to liquid. The *plastic limit* is the moisture content at which the consistence of the soil material changes from semisolid to plastic. The *liquid limit* is the moisture content at which the consistence changes from plastic to liquid. The *plasticity index* is the numerical difference between the liquid limit and the plastic limit. It indicates

the range of moisture content within which the soil material is plastic.

### **Engineering interpretations**

Table 6 shows the suitability of the soils for various engineering uses. Soil features that affect the selection and application of various kinds of land treatment have been considered. Five of the soils listed in table 6 occur only in the part of the county that was surveyed by the reconnaissance method. They do not appear on the map as separate soils, since only soil associations were mapped in the reconnaissance part of the survey.

### **Genesis and Morphology of the Soils**

The first part of this section describes the factors of soil formation and their effect on the soils in Crow Wing County. The second part discusses the morphology of the soils.



## test data

procedures of American Association of State Highway Officials (AASHO)]

Mechanical analysis <sup>2</sup>														Liqu- id limit	Plas- ticity index	Classification		
Percentage of fraction passing sieve—											Percentage smaller than—					AASHO	Unified	
3- in.	2- in.	1½- in.	1- in.	¾- in.	⅜- in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.					0.002 mm.
-----	100	99	97	96	93	91	89	75	61	40	36	20	10	6	15	2	A-4(1)-----	SM.
-----	100	99	98	97	93	89	83	62	47	27	22	13	9	7	16	2	A-2-4(0)---	SM.
100	95	90	88	87	84	81	77	58	45	25	22	15	10	8	17	4	A-2-4(0)---	SM-SC.
100	98	98	95	94	92	89	84	65	50	26	23	13	8	6	<sup>3</sup> NP	<sup>3</sup> NP	A-2-4(0)---	SM.
-----	100	99	98	96	94	91	86	64	48	22	19	13	9	7	NP	NP	A-2-4(0)---	SM.
100	97	97	95	94	91	88	84	64	48	24	20	13	8	7	NP	NP	A-2-4(0)---	SM.
-----	100	99	97	96	95	94	92	80	69	44	36	22	10	6	16	2	A-4(2)-----	SM.
-----	100	99	97	96	92	89	86	70	56	30	27	15	9	8	15	1	A-2-4(0)---	SM.
-----	100	98	96	95	92	89	84	64	49	27	24	15	10	8	17	4	A-2-4(0)---	SM-SC.
100	99	98	96	95	93	91	89	84	76	61	56	40	20	12	21	3	A-4(5)-----	ML.
-----	-----	-----	-----	100	99	98	97	94	92	86	84	76	63	48	46	22	A-7-6(14)---	CL.
-----	-----	-----	-----	-----	-----	-----	100	99	99	98	98	94	80	61	62	32	A-7-5(20)---	<sup>4</sup> MH-CH.
-----	-----	100	99	98	96	95	94	89	84	63	60	45	26	16	25	5	A-4(6)-----	ML-CL.
-----	-----	-----	-----	-----	-----	-----	100	98	96	89	87	75	63	50	47	22	A-7-6(14)---	CL.
-----	-----	-----	-----	-----	-----	-----	100	98	96	90	87	75	60	43	43	21	A-7-6(13)---	CL.
-----	100	99	97	96	93	90	86	78	71	58	52	28	13	8	18	3	A-4(5)-----	ML.
-----	-----	-----	100	99	97	96	95	92	88	79	75	60	50	41	42	20	A-7-6(12)---	CL.
-----	-----	-----	-----	100	99	98	96	90	84	70	65	51	34	24	27	11	A-6(7)-----	CL.

analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from

calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

<sup>3</sup> NP stands for nonplastic.

<sup>4</sup> SCS and BPR have agreed to consider that all soils having plasticity indexes within two points from A-line are to be given a borderline classification.

## Factors of Soil Formation

The soil in any given place is a function of the five factors of soil formation: parent material, climate, vegetation, topography, and time. All five of these factors are important in the genesis of every soil. The importance of each, however, differs from place to place. In extreme cases one factor may dominate in the formation of a soil and fix most of its properties, as is common where the parent material is pure quartz sand. Little can happen to quartz sand, and the soils derived from it generally have faint horizons. Even in quartz sand, however, distinct profiles can be formed under some types of vegetation where the topography is low and flat and the water table is high. Thus, for every soil the past combination of the five major factors is of the first importance to its present character.

*Parent material.*—The parent materials of the soils in Crow Wing County were deposited by glaciers. Two major types of glacial till are found in the county. Brown sandy till of the Cary age is common in the Brainerd

drumlin field. Red clay till of the Mankato age occurs in the morainic hills in the east-central part of the county. It is mixed with outwash materials in places and is nearly stone free. Outwash is common in the county; it ranges from well-sorted fine sand to poorly sorted coarse gravel.

*Climate.*—Crow Wing County has a continental climate characterized by warm summers and cold winters. Temperatures are slightly lower in the northern part, but otherwise the climate is fairly uniform throughout the county. There is no evidence of a great change in climate during the time the soils have been forming; thus, climate was not a major factor in producing differences among the soils.

More detailed information about the climate of Crow Wing County is given in the section "General Nature of the County."

*Vegetation.*—What is now Crow Wing County was primarily a forested region. The only prairie was southwest of Brainerd in a sandy area bordering the Mississippi River. The original vegetation on the sandy soils consisted mostly of pine, especially jack pine. Some red

TABLE 6.—*Engineering*

Soil type	Suitability of soil for—				
	Sand and gravel	Upper part of of roadway	Embankments and dikes	Water impoundment	Sprinkler irrigation
Alluvial land.....	Not suitable.....	Variable.....	Variable.....	Variable.....	Variable.....
Barrows loam and sandy loam.....	Not suitable.....	Fair.....	Good.....	Good.....	Not suitable.....
Brainerd sandy loam.....	Not suitable.....	Fair.....	Good.....	Good.....	Suitable.....
Burkhardt sandy loam.....	Suitable for gravel.....	Good.....	Fair.....	Poor.....	Suitable.....
Chetek gravelly loamy sand.....	Suitable for gravel.....	Good.....	Fair.....	Poor.....	Suitable.....
Chetek sandy loam.....	Suitable for gravel.....	Good.....	Fair.....	Poor.....	Suitable.....
Croswell loamy sand <sup>1</sup> .....	Suitable for sand.....	Good.....	Fair.....	Poor.....	Suitable.....
Dean Lake loamy sand <sup>1</sup> .....	Suitable for sand; has high water table.....	Fair.....	Good.....	Fair.....	Suitable if drained.....
Halder loam.....	Suitable for gravel; has high water table.....	Good.....	Fair.....	Poor.....	Suitable.....
Hibbing silt loam.....	Not suitable.....	Not suitable.....	Good.....	Good.....	Suitable.....
Hubbard loamy sand.....	Suitable for sand.....	Fair; erodible.....	Good.....	Poor.....	Suitable.....
Iosco loamy sand, shallow.....	Not suitable.....	Not suitable.....	Good.....	Good.....	Suitable.....
Isanti sandy loam.....	Suitable for sand; has high water table.....	Fair.....	Fair.....	Fair.....	Suitable if drained.....
Lake beaches.....	Suitable for sand.....	Fair.....	Poor.....	Poor.....	(Nonagricul- tural.).....
Lino loamy sand.....	Suitable for sand; has high water table.....	Fair.....	Fair.....	Poor.....	Suitable.....
Marsh.....	Not suitable.....	Not suitable.....	Poor.....	Fair.....	Suitable if drained.....
Menahga loamy sand and sand.....	Suitable for sand.....	Fair to good; erodible.....	Fair.....	Poor.....	Suitable.....
Merrifield loamy sand <sup>1</sup> .....	Uppermost 3 to 4 feet suitable for sand.....	Fair; erodible.....	Fair.....	Fair.....	Suitable.....
Nisswa loamy sand <sup>1</sup> .....	Uppermost 3 to 4 feet suitable for sand.....	Fair; erodible.....	Fair.....	Poor.....	Suitable.....
Nokasippi sandy loam.....	Uppermost 2 to 4 feet suitable for sand.....	Good.....	Good.....	Good.....	Suitable.....
Nokay sandy loam.....	Not suitable.....	Fair.....	Good.....	Good.....	Suitable.....
Nymore loamy sand.....	Suitable for sand.....	Fair; erodible.....	Fair.....	Poor.....	Suitable.....
Onamia sandy loam.....	Suitable for gravel.....	Good.....	Fair.....	Poor.....	Suitable.....
Peat, deep.....	Not suitable.....	Not suitable.....	Poor.....	Fair.....	Suitable if drained.....
Peat, moderately shallow over clays.....	Not suitable.....	Not suitable.....	Poor.....	Fair.....	Suitable if drained.....
Peat, moderately shallow over sands.....	Not suitable.....	Not suitable.....	Poor.....	Fair.....	Suitable if drained.....
Pomroy loamy sand.....	Uppermost 3 to 4 feet suitable for sand.....	Good.....	Fair.....	Fair.....	Suitable.....
Trommald silty clay loam <sup>1</sup> .....	Not suitable.....	Not suitable.....	Good.....	Good.....	Not suitable.....
Warman loam.....	Suitable for gravel; has high water table.....	Good.....	Fair.....	Fair.....	Suitable if drained.....
Watab loamy sand.....	Not suitable.....	Fair.....	Fair.....	Good.....	Suitable if drained.....
Zim silty clay loam.....	Not suitable.....	Not suitable.....	Good.....	Good.....	Not suitable.....

<sup>1</sup> Occurs only as part of a soil association in the part of the county that was mapped in reconnaissance.

pine grew on the sandy loam soils underlain by gravel. The original forest cover on the till soils consisted of a mixture of white pine and hardwoods.

**Topography.**—Topography influences soil formation through its effect on drainage, runoff, erosion, moisture content, temperature, and plant cover. Strongly sloping soils usually have a shallower solum than nearly level soils. The influence of topography is modified by the other four factors of soil formation.

**Time.**—The length of time needed for a soil to develop depends on the other factors of soil formation. The age of the soils in Crow Wing County is estimated to be be-

tween 8,000 and 12,000 years. Only slight differences among the soils can be attributed to time.

### Morphology of the Soils

The soils in Crow Wing County vary widely in the degree to which their genetic horizons are expressed. Menahga soils, for example, have faint horizons, and Hibbing soils have very well defined ones. In addition, the soils vary in texture, structure, porosity, consistence, and color of the various horizons, their thickness, and their arrangement in the soil profile.



*interpretations*

Suitability of soil for—Continued		Agricultural drainage	Susceptibility to frost action	Compaction characteristics	Susceptibility to erosion of cuts and fills	Base needed for flexible pavement
Terracing	Septic tank disposal fields					
Not suitable.....	Not suitable.....	Variable.....	High.....	Fair.....	Slight.....	Variable.....
Not suitable.....	Not suitable.....	Needed.....	Moderate to high.....	Good.....	Slight.....	Thick.....
Suitable.....	Moderately suitable.....	Not needed.....	Moderate.....	Good.....	Slight.....	Moderate.....
Not suitable.....	Very suitable.....	Not needed.....	None.....	Good.....	Slight.....	Thin.....
Not suitable.....	Very suitable.....	Not needed.....	None.....	Good.....	Slight.....	Thin.....
Not suitable.....	Very suitable.....	Not needed.....	None.....	Good.....	Slight.....	Thin.....
Not suitable.....	Very suitable.....	Not needed.....	Slight.....	Good.....	Moderate.....	Thin.....
Not suitable.....	Not suitable.....	Needed.....	Moderate to high.....	Good.....	Moderate.....	Moderate.....
Not suitable.....	Moderately suitable.....	Not needed.....	Slight.....	Good.....	Slight.....	Thin.....
Suitable.....	Not suitable.....	Not needed.....	High.....	Fair.....	Moderate.....	Thick.....
Not suitable.....	Very suitable.....	Not needed.....	None.....	Good.....	High.....	Thin.....
Not suitable.....	Not suitable.....	Not needed.....	Moderate to high.....	Fair.....	Moderate.....	Thick.....
Not suitable.....	Not suitable.....	Needed.....	Moderate.....	Fair.....	Moderate.....	Moderate.....
Not suitable.....	Moderately suitable.....	(Nonagricultural.)	Slight.....	Fair.....	High.....	Moderate.....
Not suitable.....	Moderately suitable.....	Not needed.....	Moderate to high.....	Good.....	High.....	Moderate.....
Not suitable.....	Not suitable.....	Needed.....	High.....	Poor.....	(Not suitable for fills.)	Thick.....
Not suitable.....	Very suitable.....	Not needed.....	None.....	Good.....	High.....	Thin.....
Not suitable.....	Moderately suitable.....	Not needed.....	Moderate to high.....	Good.....	High.....	Moderate.....
Not suitable.....	Very suitable.....	Not needed.....	Slight.....	Good.....	High.....	Thin.....
Suitable.....	Not suitable.....	Not needed.....	Moderate.....	Good.....	Slight.....	Thin.....
Suitable.....	Not suitable.....	Not needed.....	Moderate.....	Good.....	Slight.....	Moderate.....
Not suitable.....	Very suitable.....	Not needed.....	Slight.....	Good.....	High.....	Thin.....
Not suitable.....	Very suitable.....	Not needed.....	Moderate in upper 24 inches, slight below that.	Good.....	Slight.....	Thin.....
Not suitable.....	Not suitable.....	Needed.....	High.....	Poor.....	(Not suitable for fills.)	Thick.....
Not suitable.....	Not suitable.....	Needed.....	High.....	Poor.....	(Not suitable for fills.)	Thick.....
Not suitable.....	Not suitable.....	Needed.....	High.....	Poor.....	(Not suitable for fills.)	Thick.....
Suitable.....	Moderately suitable.....	Not needed.....	Slight.....	Good.....	Slight.....	Thin.....
Not suitable.....	Not suitable.....	Needed.....	High.....	Fair.....	Moderate.....	Thick.....
Not suitable.....	Not suitable.....	Needed.....	Moderate to high.....	Good.....	Slight.....	Moderate.....
Not suitable.....	Not suitable.....	Needed.....	Moderate.....	Good.....	Slight.....	Moderate.....
Suitable.....	Not suitable.....	Not needed.....	High.....	Fair.....	Moderate.....	Thick.....

In the pages that follow, a representative profile of each soil series mapped in the county is described. The location of each profile is given by land description (section, township, and range). Unless otherwise indicated, the Munsell notations are for moist soil.

**BARROWS SERIES:** This series consists of poorly drained and very poorly drained Low-Humic Gley soils that developed from acid, sandy till. These soils are of minor extent and of little importance in the county. They are members of the catena that includes the moderately well drained Brainerd soils and the somewhat poorly drained Nokay soils. Barrows soils have prominent Ap and A2

horizons and a color B horizon. The lower part of the B horizon is cemented and has some characteristics of a fragipan.

Profile of Barrows loam in a cultivated field (SW $\frac{1}{4}$  SW $\frac{1}{4}$  sec. 28, T. 45 N., R. 30 W.):

Ap—0 to 8 inches, very dark brown (10YR 2/2) to black (2.5Y 2/0) loam; massive; friable; strongly acid; abrupt, smooth boundary.

A21g—8 to 15 inches, grayish-brown (2.5Y 5/2) sandy loam; weak, very thin, platy structure; friable; old root channels filled with dark reddish-brown (5YR 3/4) sandy loam; strongly acid; clear, wavy boundary.

A22g—15 to 18 inches, grayish-brown (10YR 5/2) sandy loam with fine, distinct, dark reddish-brown (5YR 3/4) mottles making up about 20 percent of the mass; weak, very fine, subangular blocky structure to single grained; friable; very strongly acid; clear, wavy boundary.

B11—18 to 25 inches, yellowish-red (5YR 4/6 to 4/8) sandy loam with fine, distinct mottles of grayish brown making up about 20 percent of the mass; weak, very fine, subangular blocky structure to single grained; friable; very strongly acid; gradual, wavy boundary.

B12—25 to 31 inches, yellowish-red (5YR 4/6 to 4/8) sandy loam with many, medium, distinct mottles of grayish brown; weak, fine, subangular blocky structure to single grained; friable to firm; very strongly acid; gradual, wavy boundary.

B13x—31 to 36 inches, dark-brown (7.5YR 4/4) sandy loam with channels and splotches ( $\frac{1}{4}$  to  $\frac{1}{2}$  inch in cross section) of light gray (10YR 7/2); moderate, thick, platy structure that breaks to weak, fine, subangular blocky; firm; weakly cemented; strongly acid; gradual, wavy boundary.

C—36 inches +, dark yellowish-brown (10YR 4/4) sandy loam with channels and splotches of light gray (10YR 7/2); weak to moderate, thin and medium, platy structure that breaks to weak, very fine, subangular blocky; firm to friable; medium acid.

*Range in characteristics:* The texture of the A horizon ranges from loam to sandy loam. The color of the B horizon, and that of the underlying till, ranges from 10YR to 5YR in hue.

**BRAINERD SERIES:** This series consists of moderately well drained soils that developed from brown, noncalcareous, glacial till. These soils are tentatively classified as Sols Bruns Acides. They are important agricultural soils in Crow Wing County, and they occupy a fairly large acreage. They are members of the drainage sequence that includes the somewhat poorly drained Nokay soils. Brainerd soils lack a textural B horizon, and they have a fragipan at a depth of 18 to 24 inches. The degree of base saturation ranges from more than 25 percent in the surface horizon to more than 70 percent in the C horizon.

Profile of Brainerd sandy loam in an undisturbed area (NE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 28, T. 45 N., R. 30 W.):

O1—1 inch to 0, very dark brown (10YR 2/2) mass of leaf litter, stems, and roots.

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) sandy loam; weak, very fine, subangular blocky structure; friable; roots plentiful; very strongly acid; clear, wavy boundary.

A2—5 to 10 inches, dark grayish-brown (10YR 4/2) to dark-brown (10YR 4/3) sandy loam; weak, thin, platy structure; friable; roots plentiful; strongly acid; gradual, wavy boundary.

B1—10 to 18 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, thin and medium, platy structure to massive; friable; some evidence of weak cementation; few roots; strongly acid; gradual, wavy boundary.

B1x—18 to 22 inches, dark-brown (7.5YR 4/4) sandy loam; common, medium, faint mottles of brown (10YR 5/3); massive or weak, thick, platy structure that breaks to moderate, fine, angular blocky; friable to firm; few roots; medium acid to strongly acid; clear, wavy boundary.

B2x—22 to 28 inches, reddish-brown (5YR 4/4) to dark-brown (7.5YR 4/4) sandy loam that crushes to dark brown (7.5YR 4/4); weak, thick, platy structure to massive; firm and brittle; weakly cemented; medium acid to strongly acid; clear, wavy boundary.

B3x—28 to 34 inches, dark-brown (7.5YR 4/4) sandy loam with channels and spots of pinkish gray (7.5YR 6/2); weak, thick, platy structure to massive; firm; several root channels about  $\frac{1}{4}$  inch in diameter that are yellowish red (5YR 4/6) around the edges; medium acid; clear, wavy boundary.

C1x—34 to 40 inches, yellowish-red (5YR 4/6) sandy loam with masses and spots of pinkish gray (7.5YR 6/2) and pockets of sand; massive; firm; medium acid.

C2x—40 to 48 inches, dark-brown (7.5YR 4/4) sandy loam with some sand pockets; appears massive but can be chipped out as plates that break down to weak or moderate, very fine, subangular blocky.

*Range in characteristics:* This soil ranges from slightly stony to very stony. The A horizon consists of loam or sandy loam. The pinkish-gray spots and channels in the B3x and C1x horizons range from few to many. Base status ranges from 27 to 34 percent saturation in the A horizon, from 50 to 60 percent in the B horizon, and from 65 to 75 percent in the C horizon. The C horizon is more than 12 feet thick in some places.

**BURKHARDT SERIES:** This series consists of Brunizems that developed from sandy and gravelly outwash on outwash plains and stream terraces. These soils are of minor extent in the county. They are associated with Onamia and Chetek soils. Burkhardt soils have a very weak textural B horizon; their parent rock contains much crystalline gravel but little or no limestone.

Profile of Burkhardt sandy loam in a disturbed area (west side of NW $\frac{1}{4}$  sec. 6, T. 43 N., R. 30 W.):

A1—0 to 9 inches, very dark brown (10YR 2/2) coarse sandy loam; weak, fine, granular structure; loose; abrupt, smooth boundary.

A3—9 to 14 inches, dark-brown (10YR 3/3) loamy coarse sand; single grained; loose; clear, wavy boundary.

B1—14 to 18 inches, brown (10YR 4/3) loamy coarse sand; single grained; slightly hard; clear, smooth boundary.

B2—18 to 25 inches, dark-brown (7.5YR 4/4) gravelly loamy coarse sand; single grained; slightly hard; abrupt, clear boundary.

IIC1—25 to 35 inches, dark-brown (7.5YR 4/4) gravelly coarse sand; single grained; loose; clear, smooth boundary.

IIC2—35 inches +, yellowish-brown (10YR 5/4) coarse sand; single grained; loose.

*Range in characteristics:* The color and texture of the A horizon vary from place to place, as do the thickness and coherence of the B horizon. The amount of fine gravel in the IIC horizon also varies. The color of the IIC horizon ranges from 7.5YR to 5YR in hue, but it may be 10YR in places.

**CHETEK SERIES:** This series consists of well-drained to excessively drained, weakly developed soils that formed from noncalcareous, sandy and gravelly outwash and drift containing many crystalline rocks. These soils are classified as Gray-Brown Podzolic soils but are on the borderline between Podzols and Gray-Brown Podzolic soils because they developed in a cool, humid climate. Because they are shallow over a gravelly and sandy substratum, these soils are somewhat droughty. Nevertheless, they are of considerable agricultural importance in the county. They occupy a large acreage.

Chetek soils are members of the catena that includes the poorly drained Warman soils. They are associated with Onamia soils. They are shallower to the coarse-textured substratum (IIC horizon) than Onamia soils, and they have a thinner or less well developed B horizon.

Profile of Chetek sandy loam in a cultivated area (SE cor. of SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 22, T. 46 N., R. 29 W.):

Ap—0 to 5 inches, very dark grayish-brown (10YR 3/2) to dark-brown (10YR 3/3) sandy loam; weak, very fine, subangular blocky structure to massive; friable; roots plentiful; medium acid; abrupt, smooth boundary.



- A2—5 to 8 inches, brown (10YR 4/3 to 5/3) sandy loam; weak, very thin, platy structure to massive; friable; roots plentiful; medium acid; gradual, wavy boundary.
- B1—8 to 14 inches, dark-brown (7.5YR 4/4) to brown (7.5YR 5/4) sandy loam; weak, fine, subangular blocky structure; friable; roots plentiful; medium acid; gradual, wavy boundary.
- B2—14 to 19 inches, dark reddish-brown (5YR 3/4) to reddish-brown (5YR 4/4) sandy clay loam; massive; hard when dry, friable when moist, and slightly plastic and slightly sticky when wet; roots plentiful; medium acid to strongly acid; gradual, wavy boundary.
- B3—19 to 21 inches, dark reddish-brown (5YR 3/4) sandy loam; massive; hard when dry, friable when moist; few roots; strongly acid; gradual, wavy boundary.
- IIC—21 inches +, yellowish-red (5YR 4/6) sand and gravel; single grained; loose; medium acid.

*Range in characteristics:* The texture of the A horizon ranges from loam to gravelly loamy sand. In places, the B and C horizons may be 7.5YR in hue. Depth to the C horizon ranges from 15 to 24 inches. The number of cobblestones ranges from very few to many. In some areas one or more of the lower layers may be about 25 percent cobblestones.

**CROSWELL SERIES:** This series consists of moderately well drained Podzols that formed from deep, sorted, acid sand. These soils are members of the catena that includes the very poorly drained Dean Lake soils. Croswell soils are of minor extent in the county and of minor agricultural importance.

Profile of Croswell sand in an undisturbed area (NE. cor. of NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 11, T. 47 N., R. 28 W.):

- O2—1 inch to 0, very dark gray (10YR 3/1) to black (10YR 2/1), granular, finely divided organic matter.
- A2—0 to 5 inches, grayish-brown (10YR 5/2) sand; single grained; loose; roots plentiful; very strongly acid; abrupt, irregular boundary.
- B2irh—5 to 11 inches, dark-brown (7.5YR 4/4) sand; weak, very fine, granular structure to single grained; loose; roots plentiful; strongly acid; clear, wavy boundary.
- B31—11 to 17 inches, brown (10YR 5/3) to dark yellowish-brown (10YR 4/4) sand; single grained; loose; few roots; very strongly acid; clear, smooth boundary.
- B32—17 to 28 inches, mixed yellowish-brown (10YR 5/4) and dark yellowish-brown (10YR 4/4) sand; single grained; loose; very strongly acid; gradual, wavy boundary.
- B33ir—28 to 40 inches, mixed yellowish-red (5YR 4/6 to 4/8) sand (60 percent) and brown (10YR 5/3) sand (40 percent); massive; firm; very strongly acid.
- C—40 inches +, brown (10YR 5/3) to grayish-brown (10YR 5/2) sand; single grained; loose; wet.

*Range in characteristics:* The B31 horizon is weakly developed to strongly developed. The B33ir horizon is friable to firm.

**DEAN LAKE SERIES:** This series consists of Low-Humic Gley soils that intergrade to Bog soils. These soils developed in deep sand at the edges of old lake basins and of streams. They are poorly drained or very poorly drained and are geographically associated with the moderately well drained Croswell soils. Dean Lake soils have a thin layer of muck and peat over variable colored, medium and coarse sand. They make up only a small part of the county's acreage and have little agricultural value.

Profile of Dean Lake sand in an undisturbed area (SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 13, T. 47 N., R. 28 W.):

- O2—6 inches to 0, black (N 2/1) muck; weak, fine, granular structure to massive; contains some fine mineral material; abrupt, wavy boundary.

- A21g—0 to 10 inches, grayish-brown (2.5Y 5/2) coarse sand with a few light olive-brown (2.5Y 5/6) spots; single grained; loose; medium acid; abrupt, wavy boundary.
- A22g—10 to 12 inches, grayish-brown (10YR 5/2) to brown (10YR 5/3) medium sand; single grained; loose; root channels are lined with greenish gray (5GY 5/1); medium acid; clear, wavy boundary.
- ACg—12 to 16 inches, equal parts of olive-gray (5Y 4/2) and reddish-brown (5YR 4/4) to yellowish-red (5YR 4/6) medium sand mixed in bands and streaks; single grained; loose; strongly acid; clear, wavy boundary.
- C1g—16 to 40 inches, mixed dark-gray (5Y 4/1) sand (70 percent) and dark yellowish-brown (10YR 4/4) sand (30 percent); single grained; loose; medium acid.
- C2g—40 inches +, dark-gray (N 4/0) coarse sand; single grained; loose.

*Range in characteristics:* The O2 horizon ranges from 2 to 10 inches in thickness. Layers of black organic material may occur as thin (1 inch), discontinuous streaks anywhere within 16 inches below the surface. These streaks may be horizontal or may be at any angle.

**HALDER SERIES:** This series consists of somewhat poorly drained Gray-Brown Podzolic soils that developed in medium-textured sediments over sandy and gravelly glacial outwash. These soils occur in slightly depressed areas on outwash plains and on low stream terraces. They are closely associated with the well-drained Onamia soils and the poorly drained and very poorly drained Warman soils. Halder soils are of minor extent in the county and of minor agricultural importance.

Profile of Halder loam (SE. cor. of SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 19, T. 44 N., R. 28 W.):

- Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loam; weak, thin, platy structure; friable; abrupt, smooth boundary.
- A2g—7 to 14 inches, light brownish-gray (10YR 6/2) loam with common, medium, distinct, yellowish-brown (10YR 5/6) mottles; moderate, thin, platy structure; friable; clear, smooth boundary.
- IIB1—14 to 17 inches, mixed dark reddish-brown (5YR 3/4) and reddish-gray (5YR 5/2) gravelly sandy loam; massive; firm; diffuse boundary.
- IIB2—17 to 24 inches, dark reddish-brown (5YR 3/4) gravelly sandy loam; massive; slightly cemented; abrupt, smooth boundary.
- IIC—24 inches, yellowish-red (5YR 4/6) sand and gravelly sand; single grained; loose.

*Range in characteristics:* The depth to the loose, stratified IIC horizon ranges from 24 to 42 inches. The texture of the B horizon ranges from sandy loam to sandy clay loam.

**HIBBING SERIES:** This series consists of moderately well drained and well drained Gray Wooded soils. These soils formed from slightly calcareous silty clay till that had been leached to a depth of about 40 inches. They occupy a limited acreage in the county, mostly on moraines around lake plains, and they are of minor agricultural importance. They have strongly developed horizons, particularly the A2.

Profile of Hibbing silt loam in an undisturbed area (SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 27, T. 136 N., R. 26 W.):

- O1—2 inches to 0, layer on forest floor consisting mainly of deciduous leaf litter.
- A2—0 to 7 inches, reddish-gray (5YR 5/2) silt loam; moderate, thin, platy structure; friable; roots plentiful; strongly acid; gradual, wavy boundary.
- B & A—7 to 9 inches, light reddish-brown (5YR 6/3) and reddish-brown (5YR 4/3) silt loam and silty clay; firm blocks; roots plentiful; very strongly acid; gradual, wavy boundary. (This horizon is a mixture of

bleached material similar to that of the A2 horizon and of nodular or blocky remnants similar to those in the B21 horizon.)

B21—9 to 16 inches, reddish-brown (5YR 4/3) silty clay; reddish brown (5YR 5/4) when crushed; moderate, medium, angular blocky structure; firm; roots plentiful; strongly acid; gradual, smooth boundary.

B22—16 to 33 inches, dark reddish-brown (5YR 3/4) silty clay; reddish brown (5YR 4/4) when crushed; moderate, fine, prismatic structure breaking to strong, medium, angular blocky; very firm; roots plentiful on faces of prisms and blocks; strongly acid; gradual, smooth boundary.

B3—33 to 42 inches, reddish-brown (5YR 4/4) silty clay; moderate, fine, subangular blocky structure; very firm; roots plentiful on faces of blocks; slightly acid to medium acid; gradual, smooth boundary.

C—42 to 64 inches, reddish-brown (5YR 4/3) silty clay with noticeable amount of sand and fine gravel; moderate, fine, subangular blocky structure; firm; calcareous.

*Range in characteristics:* The texture of the A2 horizon ranges from silty clay loam to silt loam. A silt cap 2 to 8 inches thick may be present. The B & A horizon may be a true mixture of A2 material around nodular remnants of the B, or it may be a transition layer in which material is filtering down from the A2 horizon around faces and blocks of the B2. The parent material ranges from brown (10YR and 7.5YR) hues to dark reddish brown (2.5YR and 5YR) hues.

**HUBBARD SERIES:** This series consists of Brunizems that developed in sandy glacial outwash that is of mixed lithological composition but is largely silicate minerals. These soils occur southwest of Brainerd. They have only a slight or no textural B horizon. The B horizon, however, does have a slightly brighter color (higher chroma) than the A1 horizon, and it is slightly hard when dry. Hubbard soils differ from Nymore soils in having a thicker A1 horizon.

Profile of Hubbard loamy sand in an undisturbed area (SE $\frac{1}{4}$  sec. 25, T. 44 N., R. 32 W.):

A1—0 to 14 inches, very dark brown (10YR 2/2) loamy sand; weak, fine, granular structure; friable; clear, smooth boundary.

B2—14 to 18 inches, very dark grayish-brown (10YR 3/2) loamy sand; single grained; cohesive when moist; slightly hard; clear, smooth boundary.

B3—18 to 26 inches, dark-brown (10YR 4/3) sand; single grained; cohesive when moist; slightly hard; clear, smooth boundary.

C1—26 to 36 inches, brown (10YR 4/3) sand; single grained; loose; gradual boundary.

C2—36 inches +, brown (10YR 5/3) sand; single grained; loose.

*Range in characteristics:* The texture of the A1 horizon ranges from sand to loamy sand or, in places, sandy loam. The thickness of the A1 ranges from 10 to 20 inches. The B horizon ranges from dark brown (10YR 3/3) to reddish brown (5YR 4/3). In places, lenses or layers of sandy loam occur in the C horizon. A small amount of gravel may be included in the parent materials. Hubbard soils are usually calcareous at a depth of 4 to 6 feet.

**IOSCO SERIES:** This series consists of somewhat poorly drained Podzols that developed in 24 inches or less of sandy outwash over moderately fine textured material. These soils occur along lakeshores and as delta deposits in old glacial lakes. They are of minor extent and of little importance in the county.

Iosco soils show moderate horizonation. Their B horizon has little or no cementation. They are better drained

than Dean Lake soils and, unlike Dean Lake soils, have fine-textured material within 4 feet of the surface.

Profile of Iosco loamy sand in a pasture (SW $\frac{1}{4}$  sec. 20, T. 136 N., R. 25 W.):

A1—0 to 3 inches, black (10YR 2/1) loamy sand; weak, very fine, subangular blocky structure; friable; roots plentiful; strongly acid; abrupt, wavy boundary.

A2g—3 to 7 inches, light brownish-gray (2.5Y 6/2) sand; single grained; loose; roots plentiful; strongly acid; abrupt, wavy boundary.

B2ir—7 to 14 inches, brown (10YR 4/3) loamy sand with a few, large, prominent mottles of dark reddish brown (5YR 3/4); single grained; loose; few roots; medium acid; gradual, smooth boundary.

B3—14 to 15 inches, brown (10YR 4/3) loamy sand with common, medium, prominent mottles of dark reddish brown (5YR 3/4); single grained; loose; medium acid; abrupt, smooth boundary.

IIC1g—15 to 17 inches, grayish-brown (2.5Y 5/2) loam to clay loam with many, fine, prominent mottles of strong brown (7.5YR 5/8); weak, fine, subangular blocky structure; plastic when wet; medium acid; clear, smooth boundary.

IIC2g—17 to 29 inches, dark grayish-brown (2.5Y 4/2) clay loam with common, fine, prominent mottles of strong brown (7.5YR 5/6); weak, fine, subangular blocky structure; plastic when wet; gradual, wavy boundary.

IIC3g—29 inches +, olive-gray (5Y 5/2) clay loam with common, fine, prominent mottles of yellowish brown (10YR 5/8); massive; plastic when wet; weakly calcareous.

*Range in characteristics:* The texture of the A1 horizon ranges from sandy loam to loamy sand. Depth to the IIC horizon varies from 8 to about 24 inches within short distances. The B horizon is weakly cemented in places. Depth to ground water ranges from 40 to 60 inches.

**ISANTI SERIES:** This series consists of Humic Gley soils that developed from deep sand, largely of quartz lithology. These soils occupy slight depressions in sandy outwash. They are of minor extent in the county and of minor agricultural importance. They consist of a black or nearly black A1 horizon over gray sand or loamy sand. They have a high water table. Isanti soils are associated with the excessively drained Menahga soils and the somewhat poorly drained Lino soils. They differ from Lino soils in having a thicker A1 horizon and in being more poorly drained.

Profile of Isanti sandy loam (SE $\frac{1}{4}$  sec. 20, T. 44 N., R. 31 W.):

A11—0 to 9 inches, black (5Y 2/1) mucky sandy loam; moderate, very fine, subangular blocky structure; friable; abundant roots; neutral to slightly acid; abrupt, smooth boundary.

A12—9 to 13 inches, very dark gray (5Y 3/1) sandy loam with common, medium, distinct mottles of dark reddish brown (5YR 3/3); single grained; friable; roots plentiful; slightly acid; gradual, wavy boundary.

Bg—13 to 18 inches, dark grayish-brown (2.5Y 4/2) sandy loam with common, medium, distinct mottles of yellowish red (5YR 4/6); single grained; friable; few roots; slightly acid to medium acid; gradual, wavy boundary.

C1g—18 to 27 inches, dark yellowish-brown (10YR 4/4) sand with a few, fine, distinct mottles of strong brown (7.5YR 5/8); single grained; loose; slightly acid.

C2g—27 inches +, pale-brown (10YR 6/3) sand with a few, fine, faint mottles of yellowish brown (10YR 5/4); single grained; loose; neutral.

*Range in characteristics:* The texture of the A1 horizon ranges from sandy loam to loamy sand. The color



of the C horizon ranges from grayish brown (10YR 5/2) to dark grayish brown (10YR 4/2). In scattered locations, there may be a thin, discontinuous layer of dark reddish-brown cemented sand, or ortstein. Depth to the water table in undrained areas ranges from 15 to 30 inches. Under native cover, these soils may have a 6- to 8-inch layer of organic matter on the surface.

**LINO SERIES:** This series consists of Low-Humic Gley soils that developed from sand, largely of quartz lithology. These soils have an AC horizon sequence. They are strongly acid or medium acid to a depth of 4 to 5 feet; below that they may be slightly acid or neutral. These soils are the somewhat poorly drained associates of the excessively drained Menahga and Nymore soils and the very poorly drained Isanti soils. They have a thinner and lighter colored A1 horizon than Isanti soils.

Profile of Lino loamy sand in a disturbed area (SW $\frac{1}{4}$ -NW $\frac{1}{4}$  sec. 21, T. 44 N., R. 31 W.):

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) loamy sand; weak, fine, granular structure; friable; clear, smooth boundary.

A3g—9 to 17 inches, dark grayish-brown (10YR 4/2) loamy sand with common, fine, distinct, yellowish-brown (10YR 5/6) mottles; single grained; loose; clear, wavy boundary.

C1g—17 to 25 inches, yellowish-brown (10YR 5/4) sand with common, medium, distinct, yellowish-red (5YR 4/8) mottles; single grained; loose; clear, smooth boundary.

C2g—25 to 33 inches, brown (10YR 5/3) and strong-brown (7.5YR 5/6) sand; single grained; loose; gradual boundary.

C3g—33 inches +, pale-olive (5Y 6/3) and light brownish-gray (10YR 6/2) sand; single grained; loose.

*Range in characteristics:* Where this soil approaches a poorly drained condition, the surface layer may be black and the subsoil gray. Where it approaches a moderately well drained condition, the surface layer is very dark grayish brown to dark brown and the subsoil is mottled dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2). Medium-sized separates predominate in the sand fraction of Lino soils where the soils are associated with Nymore and Menahga soils.

**MENAHGA SERIES:** This series consists of somewhat excessively drained or excessively drained Regosols that developed in deep, loose sand. These soils show weak horizonation. They are widely distributed in Crow Wing County and are used mainly for timber production. Menahga soils have a thinner and lighter colored A1 horizon than Nymore soils, which are prairie-border soils.

Profile of Menahga loamy sand in an undisturbed area (SE $\frac{1}{4}$ SE $\frac{1}{4}$  of sec. 30, T. 136 N., R. 26 W.):

O1—1 inch to 0, very dark grayish-brown leaf litter and mold; many roots.

A1—0 to 2 inches, very dark brown (10YR 2/2) loamy sand, a mixture of black organic matter and bleached sand grains; single grained; loose; few roots; slightly acid to neutral; abrupt, smooth boundary.

AC1—2 to 8 inches, brown (10YR 4/3) to dark yellowish-brown (10YR 4/4) loamy sand; single grained; loose; few roots; medium acid; gradual, wavy boundary.

AC2—8 to 15 inches, dark yellowish-brown (10YR 4/4) fine sand; single grained; loose; few roots; medium acid; gradual, smooth boundary.

C1—15 to 27 inches, yellowish-brown (10YR 5/4) fine sand; single grained; loose; medium acid; gradual, smooth boundary.

C2—27 to 33 inches, yellowish-brown (10YR 5/6) sand; single grained; slightly cohesive in place but loose when disturbed; medium acid; gradual, smooth boundary.

C3—33 inches +, yellowish-brown (10YR 5/4 and 5/8) sand with some darker colored grains; single grained; loose; slightly acid to neutral.

*Range in characteristics:* The texture of the Ap horizon is loamy sand or sand. In more moist areas there may be slight evidence of a Podzol B horizon and an A2 horizon. A small amount of gravel may be encountered at a depth of 24 to 40 inches or more.

**MERRIFIELD SERIES:** This series consists of somewhat poorly drained or poorly drained Regosols that developed in fine and medium sand or loamy sand over very fine sand and silt of lacustrine origin. These soils are in the tension zone between Gray Wooded soils and Podzols. The upper part of their profile consists of loose sand or loamy sand. Below a depth of 2 to 3 feet, the sand is cemented, partly by iron. Merrifield soils are associated with the moderately well drained or well drained Nisswa soils, which are 6 inches to 2 feet higher than Merrifield soils. In Crow Wing County, Merrifield soils occupy a small acreage in a lake plain. They support hardwoods and white pine, both of which generally do not grow on sandy soils in this area.

Profile of Merrifield loamy sand in a pastured woodland (SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 19, T. 135 N., R. 27 W.):

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, very fine, subangular blocky structure; friable; few tree roots; grass roots plentiful; slightly acid; clear, wavy boundary.

A2—6 to 14 inches, dark-brown (10YR 4/3) sand with a few, fine, faint mottles of yellowish brown (10YR 5/6); single grained; loose; few roots; numerous bleached sand grains; medium acid; clear, smooth boundary.

AC—14 to 26 inches, brown (10YR 5/3) sand with a few, medium, distinct mottles of dark brown (7.5YR 4/4) and common, medium, faint mottles of yellowish brown (10YR 5/6); single grained; loose; few roots; strongly acid; abrupt, irregular boundary.

C1x—26 to 33 inches, pale-brown (10YR 6/3) sand; weakly cemented; some hard, dark-brown (10YR 3/3) concretions of iron; strongly acid; abrupt, irregular boundary.

C2x—33 to 42 inches, dark-brown (7.5YR 4/4) sand; moderate, thick, platy structure; firm; strongly cemented; no roots; very strongly acid; abrupt, smooth boundary.

IIC—42 inches +, light brownish-gray (2.5Y 6/2) loamy very fine sand with many, medium, prominent mottles of yellowish red (5YR 4/6); moderate, thin, platy structure or stratification; medium acid.

*Range in characteristics:* The texture of the Ap horizon is loamy sand or sand. The IIC horizon may consist of fine sand, very fine sand, very fine sandy loam, silt, silt loam, or loamy very fine sand.

**NISSWA SERIES:** This series consists of moderately well drained or well drained soils that developed in fine and medium sand or loamy sand over very fine sand and some silt of lacustrine origin. These soils are in the tension zone between Gray Wooded soils and Podzols. The upper part of their profile consists of loose sand or loamy sand, but in the lower part there is a cemented layer similar to a fragipan. Nisswa soils are associated with Merrifield soils. They are better drained than Merrifield soils, and they occur at slightly higher elevations. In Crow Wing County, Nisswa soils occupy a small acreage in a lake plain.

Profile of Nisswa loamy sand in an undisturbed area (NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 19, T. 135 N., R. 27 W.):

- O2—2 inches to 0, organic matter formed from decomposed deciduous forest floor.
- A2—0 to 5 inches, grayish-brown (10YR 5/2) to dark grayish-brown (10YR 4/2) loamy sand; single grained; loose; roots plentiful; very strongly acid; clear, wavy boundary.
- AC1—5 to 11 inches, grayish-brown (10YR 5/2) to brown (10YR 5/3) sand; very weak, medium, subangular blocky structure to single grained; loose; roots plentiful; medium acid to strongly acid; clear, wavy boundary.
- AC2—11 to 16 inches, brown (10YR 5/3) sand; very weak, medium, subangular blocky structure to single grained; loose; roots plentiful; medium acid to strongly acid; clear, wavy boundary.
- C1—16 to 32 inches, pale-brown (10YR 6/3) sand; very weak, fine, subangular blocky structure to single grained; loose; few roots; strongly acid; gradual, smooth boundary.
- C2—32 to 38 inches, yellowish-brown (10YR 5/4) sand with common, medium, prominent mottles of strong brown (7.5YR 5/6) and yellowish red (5YR 5/6); single grained; loose; strongly acid; abrupt, smooth boundary.
- C3x—38 to 44 inches, strong-brown (7.5YR 5/6) loamy sand; strong, thick, platy structure; firm; weakly cemented; very strongly acid; abrupt, smooth boundary.
- IIC4—44 inches +, grayish-brown (2.5Y 5/2) very fine sand to very fine sandy loam with many, medium, prominent mottles of strong brown (7.5YR 5/6); moderate, thin, platy structure or stratified; firm; very strongly acid.

*Range in characteristics:* The texture of the A2 horizon is loamy sand or sand. The fragipanlike C3x horizon is weakly cemented to strongly cemented. The IIC4 horizon may contain some coarse silt.

**NOKASIPPI SERIES:** This series consists of Humic Gley soils that developed in 2 or 3 feet of sand or loamy sand over brown, acid, sandy loam to clay loam till. These soils occur in association with the moderately well drained or well drained Pomroy soils and the somewhat poorly drained Watab soils. They differ from these soils in having a thicker and darker colored A horizon and in being more poorly drained. Nokasippi soils are associated geographically with Barrows soils. They differ from Barrows soils in having 2 or 3 feet of loamy sand or sand over the acid, brown till. These soils are of minor extent and of little importance in the county.

Profile of Nokasippi mucky sandy loam in a pasture (SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 27, T. 44 N., R. 31 W.):

- A1—0 to 7 inches, black (10YR 2/1) mucky sandy loam; very weak, very fine, subangular blocky structure to massive; friable; roots plentiful; slightly acid.
- AC—7 to 13 inches, mixed very dark gray (10YR 3/1), dark gray (10YR 4/1), and gray (10YR 5/1) loamy sand; massive; very friable when disturbed; roots plentiful; very strongly acid.
- C1g—13 to 19 inches, grayish-brown (10YR 5/2) loamy sand; massive or single grained; very friable when disturbed; roots plentiful; very strongly acid.
- C2g—19 to 29 inches, grayish-brown (10YR 5/2 to 2.5Y 5/2) loamy sand; single grained; loose; strongly acid.
- C3g—29 to 35 inches, light brownish-gray (2.5Y 6/2) loamy sand with few, fine, faint mottles of olive yellow (5Y 5/8); single grained; loose; strongly acid.
- IIC4—35 inches +, approximately an even mixture of light brownish-gray (10YR 6/2), yellowish-red (5YR 4/6), and dark reddish-brown (5YR 3/4) clay loam; massive; slightly plastic and sticky when wet; medium acid.

*Range in characteristics:* The texture of the A1 horizon is sandy loam or mucky sandy loam. In undisturbed areas a thin layer of muck may overlie the A1 horizon.

**NOKAY SERIES:** This series consists of somewhat poorly drained or poorly drained soils that developed in brown, acid, sandy loam till. These are Low-Humic Gley soils intergrading to Sols Bruns Acides. They have a higher degree of base saturation than is typical for a Sol Brun Acide. They are associated with the poorly drained and very poorly drained Barrows soils and the moderately well drained Brainerd soils. Nokay soils differ from Barrows soils in having a thinner A1 horizon and in being better drained.

Profile of Nokay sandy loam in an area of second-growth trees (SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 32, T. 45 N., R. 30 W.):

- A1—0 to 4 inches, black (10YR 2/1) sandy loam; moderate, very fine, subangular blocky structure; friable; roots plentiful; strongly acid; abrupt, smooth boundary.
- A21g—4 to 9 inches, grayish-brown (10YR 5/2) sandy loam with common, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, platy structure that breaks to weak, very fine, subangular blocky when disturbed; friable; roots plentiful; strongly acid; clear, wavy boundary.
- A22g—9 to 15 inches, brown (10YR 5/3) sandy loam with common, medium, distinct mottles of yellowish red (5YR 4/6); weak, medium, platy structure that breaks to weak, very fine, subangular blocky when disturbed; friable; very strongly acid; clear, wavy boundary.
- A3g—15 to 20 inches, light brownish-gray (10YR 6/2) sandy loam with many, medium, prominent mottles of yellowish red (5YR 4/8); weak, very fine, subangular blocky structure to massive; friable; very strongly acid; diffuse, irregular boundary.
- B1x—20 to 35 inches, dark-brown (7.5YR 4/4) sandy loam with channels of pale-brown (10YR 6/3) sandy loam tinged with yellowish red (5YR 4/6); moderate, thick, platy structure; firm; weakly cemented; strongly acid to very strongly acid; diffuse, irregular boundary.
- B2x—35 to 48 inches, dark-brown (7.5YR 4/4) sandy loam to sandy clay loam; weak, medium, subangular blocky structure; firm but brittle; weakly cemented; strongly acid; diffuse, irregular boundary.
- Cx—48 inches +, dark-brown (7.5YR 4/4) sandy loam with sandy clay channels or balls of pinkish gray (7.5YR 6/2) tinged with yellowish red (5YR 4/8); massive; firm; medium acid.

*Range in characteristics:* The texture of the A1 horizon ranges from loam to sandy loam. The combined thickness of the A22g and A3g horizons ranges from 18 to 32 inches. The quantity of pinkish-gray channels or balls of sandy clay in the Cx horizon varies considerably. In places there are stones on the surface and throughout the profile.

**NYMORE SERIES:** This series consists of moderately dark colored, sandy Regosols. These soils have weakly developed horizons, except for the A horizon. They differ from Menahga soils in having a darker colored and thicker A horizon; they differ from Hubbard soils in having a thinner and lighter colored A horizon. Nymore soils occupy a considerable acreage in Crow Wing County but add little to the agriculture of the county, because of their droughtiness.

Profile of Nymore loamy fine sand in a disturbed area (SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 10, T. 44 N., R. 31 W.):

- Ap—0 to 5 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; gray (10YR 5/1) when dry; weak, very fine, subangular blocky structure to massive; very friable; roots plentiful; bleached sand grains common; slightly acid; abrupt, smooth boundary.



- AC—5 to 11 inches, dark-brown (10YR 3/3) fine sand; grayish-brown (10YR 5/2) when dry; weak, very fine, subangular blocky structure to massive; very friable; roots plentiful; slightly acid; gradual, smooth boundary.
- C1—11 to 14 inches, dark-brown (10YR 4/3) fine sand; grayish brown (10YR 5/2) when dry; single grained; very friable but shows slight cohesion in place; slightly acid; gradual, smooth boundary.
- C2—14 to 19 inches, dark-brown (10YR 4/3) fine sand; brown (10YR 5/3) when dry; single grained; very friable to loose; slightly acid to medium acid; gradual, smooth boundary.
- C3—19 to 39 inches, dark-brown (10YR 4/3) fine sand; single grained; loose; slightly acid; gradual, smooth boundary.
- C4—39 to 66 inches, pale-brown (10YR 6/3) to brown (10YR 5/3) fine sand; single grained; loose; medium acid; gradual, smooth boundary.
- C5—66 inches +, very pale brown (10YR 7/3) to pale brown (10YR 6/3) fine sand; single grained; loose; medium acid.

*Range in characteristics:* The Ap horizon consists of loamy sand or loamy fine sand. Its thickness ranges from 6 to 12 inches. In some profiles an A2 horizon can be identified. Many bleached sand grains are present in the A1 or Ap horizon when the A2 is absent.

**ONAMIA SERIES:** This series consists of well-drained, Gray-Brown Podzolic soils that developed in noncalcareous, sandy and gravelly outwash and drift containing a large number of crystalline rocks. These soils are associated with Chetek soils, from which they differ in being deeper to the coarse-textured substratum and in having a thicker or better developed textural B horizon. They are associated also with the somewhat poorly drained Halder soils and the poorly drained and very poorly drained Warman soils. Onamia soils do not occupy a large acreage in Crow Wing County. They are well suited to the common crops.

Profile of Onamia sandy loam in a disturbed area (SE $\frac{1}{4}$  SE $\frac{1}{4}$  sec. 19, T. 44 N., R. 28 W.):

- Ap—0 to 4 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, very fine, subangular blocky structure; friable; roots plentiful; medium acid; abrupt, smooth boundary.
- A21—4 to 15 inches, brown (10YR 5/3) to dark-brown (10YR 4/3) sandy loam; weak, very thin, platy structure to single grained; very friable; roots plentiful; strongly acid; gradual, smooth boundary.
- A22—15 to 21 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) sandy loam; weak, very thin, platy structure to single grained; friable; slightly vesicular; strongly acid; clear, smooth boundary.
- B2—21 to 27 inches, dark-brown (7.5YR 4/4) to dark yellowish-brown (10YR 4/4) loam to clay loam; weak, fine and medium, subangular blocky structure; friable to firm; very strongly acid; abrupt, smooth boundary.
- IIB3—27 to 36 inches, dark-brown (7.5YR 4/4) to reddish-brown (5YR 4/4) sand and gravel; massive; slight evidence of cementation; strongly acid; gradual, smooth boundary.
- IIC—36 inches +, brown (7.5YR 5/4) to dark-brown (7.5YR 4/4) gravelly and sandy material; single grained; loose; medium acid.

*Range in characteristics:* The texture of the Ap horizon ranges from loam to sandy loam. The depth to the IIB3 horizon ranges from 24 to 40 inches. Colors in that horizon range in hue from 10YR to 5YR.

**POMROY SERIES:** This series consists of moderately well drained and well drained Regosols that developed in a cap of well-sorted sand over brown or red, sandy loam to

clay loam till. These soils have a fragipan in the underlying till. Horizonation is weak. These soils are members of a catena that includes the somewhat poorly drained Watab soils and the poorly drained and very poorly drained Nokasippi soils. Pomroy soils are of minor extent in Crow Wing County and of minor agricultural importance.

Profile of Pomroy loamy fine sand in a disturbed area (SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 17, T. 43 N., R. 30 W.):

- Ap—0 to 5 inches, very dark gray (10YR 3/1) loamy fine sand; weak, very fine, subangular blocky structure to single grained; very friable; roots plentiful; slightly acid; abrupt, smooth boundary.
- A2—5 to 9 inches, dark yellowish-brown (10YR 3/4) loamy fine sand with a few spots of very dark gray (10YR 3/1); single grained; very friable; roots plentiful; slightly acid; gradual, wavy boundary.
- C1—9 to 16 inches, dark yellowish-brown (10YR 3/4 to 4/4) loamy sand; single grained; loose; roots plentiful; medium acid; gradual, wavy boundary.
- C2—16 to 26 inches, dark yellowish-brown (10YR 4/4) loamy sand; single grained; loose; few roots; medium acid; gradual, wavy boundary.
- C3—26 to 29 inches, brown (10YR 5/3) loamy sand with common, medium, distinct mottles of dark reddish brown (5YR 3/4) to yellowish red (5YR 5/6); single grained; loose; medium acid; clear, wavy boundary.
- IIC4x—29 to 36 inches, mixed light brownish-gray (10YR 6/2) to grayish-brown (10YR 5/2) (60 percent) and dark-brown (7.5YR 4/4) (40 percent) sandy loam; many 4- to 5-inch cobblestones; firm; medium acid; gradual, wavy boundary.
- IIC5x—36 inches +, reddish-brown (5YR 4/4) sandy loam with few, small, faint mottles of light brownish gray (10YR 6/2) and dark yellowish brown (10YR 4/4); massive; firm; slightly acid.

*Range in characteristics:* The texture of the Ap horizon ranges from sandy loam to loamy sand, and that of the A2 may be either fine sand or loamy fine sand. The depth to the IIC horizon ranges from 18 to 42 inches. Colors in the IIC horizon range in hue from 10YR to 5YR. The fragipan in the IIC is weakly developed to strongly developed.

**TROMMALD SERIES:** This series consists of Low-Humic Gley soils that developed from neutral to calcareous, brown or red, silty clay or clay till. These soils are geographically associated with the moderately well drained to well drained Hibbing soils and the somewhat poorly drained Zim soils. Trommald soils are of minor extent and of little importance in Crow Wing County.

Profile of Trommald silty clay loam in an undisturbed area (NW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 35, T. 47 N., R. 28 W.):

- A0— $\frac{1}{2}$  inch to 0, leaf litter and leaf mold.
- A1—0 to 4 inches, black (5Y 2/1 to 2/0) silty clay loam; massive, but some evidence of weak, medium, subangular blocky structure; hard when dry; friable when moist; roots plentiful; medium acid; abrupt, wavy boundary.
- A2g—4 to 7 inches, gray (5Y 5/1) heavy loam; weak, very thin, platy structure; hard when dry; firm when moist; roots plentiful; strongly acid; clear, wavy boundary.
- B21g—7 to 18 inches, very dark gray (5Y 3/1) to dark-gray (5Y 4/1) heavy silty clay loam with common, fine, distinct, dark-brown (7.5YR 4/4) mottles; moderate, fine, angular blocky structure; very firm when moist; plastic and sticky when wet; few roots; strongly acid; clear, smooth boundary.
- B22g—18 to 24 inches, olive-gray (5Y 5/2) to grayish-brown (2.5Y 5/2) silty clay with common, fine, distinct mottles of dark brown (7.5YR 4/4); moderate, fine, angular blocky structure; plastic and sticky when wet; few roots; slightly acid; clear, smooth boundary.

B3g—24 to 40 inches, gray (5Y 5/1) silty clay with common, fine, distinct mottles of dark yellowish brown (10YR 4/4); moderate, fine, angular blocky structure; plastic and sticky when wet; neutral; gradual, smooth boundary.

C—40 inches +, dark yellowish-brown (10YR 4/4) silty clay with few, small, faint mottles of yellowish brown (10YR 5/6) and common, fine, distinct mottles of light gray (N 7/0) to gray (N 5/0); massive; plastic and sticky when wet; neutral.

*Range in characteristics:* The texture of the A1 horizon ranges from silt loam to silty clay loam. Hues in the C horizon range from 10YR to 7.5 YR.

**WARMAN SERIES:** This series consists of Low-Humic Gley soils that developed on sandy outwash plains in association with Onamia and Chetek soils. Warman soils are the poorly drained and very poorly drained members of both the Onamia and Chetek catenas, and they are associated with Barrows soils. They differ from Barrows soils in being underlain by loose sand and gravel rather than by firm sandy loam or sandy clay loam till. Warman soils do not have clearly defined horizons, except for the A1, which is prominent. They are not extensive or important soils in Crow Wing County.

Profile of Warman sandy loam in an undisturbed area (NW. corner, sec. 28, T. 46 N., R. 29 W.):

O2—3 inches to 0, black (N 2/0) muck; medium acid.

A1g—0 to 4 inches, very dark grayish-brown (10YR 3/2) sandy loam with few, small, faint mottles of dark yellowish brown (10YR 4/4); weak, medium, platy structure; friable; roots plentiful; strongly acid.

A2g—4 to 9 inches, light brownish-gray (2.5Y 6/2) sandy loam with common, medium, prominent mottles of dark brown (7.5YR 4/4); massive; friable; roots plentiful; strongly acid to very strongly acid.

B21g—9 to 18 inches, strong-brown (7.5Y 5/6) sandy loam with common, medium, distinct mottles of light brownish gray (10YR 6/2); weak, very fine, subangular blocky structure; friable to very friable; roots plentiful; very strongly acid.

B22g—18 to 28 inches, dark reddish-brown (5YR 3/4) to yellowish-red (5YR 4/6 to 4/8) sandy loam with common, large, prominent mottles of gray (5Y 6/1 and N 6/0); massive with some evidence of weak, medium, subangular blocky structure; friable to very friable; few roots; strongly acid.

IIC—28 inches +, dark reddish-brown (5YR 3/4) coarse sand and gravel; single grained; loose; medium acid.

*Range in characteristics:* The texture of the A1g horizon ranges from loam to sandy loam. Depth to the IIC horizon ranges from 24 to 42 inches, and hues in this layer range from 10YR to 5YR. Some stones and cobblestones may occur on the surface and in the profile.

**WATAB SERIES:** This series consists of somewhat poorly drained Low-Humic Gley soils that developed in a cap of well-sorted sand overlying till of brown or red sandy loam to clay loam. These soils are members of the catena that includes the moderately well drained and well drained Pomroy soils and the poorly drained and very poorly drained Nokasippi soils. Watab soils have a fragipan in the IIC horizon. They occupy a small acreage in Crow Wing County.

Profile of Watab loamy sand in a cultivated field (SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 23, T. 44 N., R. 31 W.):

Ap—0 to 10 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, very fine, subangular blocky structure to single grained; friable; roots plentiful; strongly acid; abrupt, smooth boundary.

A2—10 to 16 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) loamy sand with common, medium, distinct mottles of strong brown; single grained; very friable but slightly cohesive; roots plentiful; medium acid; clear, wavy boundary.

AC—16 to 21 inches, yellowish-brown (10YR 5/4) loamy sand with common, medium, distinct mottles of dark brown (7.5YR 4/4); massive; very friable; slightly cohesive; few roots; medium acid; gradual, wavy boundary.

IIC1x—21 to 23 inches, brown (10YR 5/3) sandy loam with common, medium, distinct, dark-brown (7.5YR 4/4) mottles; massive; firm; few roots; medium acid; clear, abrupt boundary.

IIC2x—23 to 32 inches, dark-brown (7.5YR 4/4) sandy loam with common, fine, distinct mottles of light brown (7.5YR 6/4) and pale brown (10YR 6/3); massive; firm; few roots; medium acid; gradual, wavy boundary.

IIC3x—32 inches +, light brownish-gray (10YR 6/2) sandy loam with many, medium, distinct mottles of yellowish red (5YR 4/6 and 4/8); massive; firm; slight evidence of horizontal breakage.

*Range in characteristics:* The A horizon consists of sandy loam or loamy sand. Thickness of the sandy upper layers ranges from 15 inches to about 24 inches.

**ZIM SERIES:** This series consists of somewhat poorly drained, Gray Wooded soils that formed in silty clay or clay till that may be calcareous at about 4 feet. These soils have distinct horizons; the A2 horizon is particularly prominent. Zim soils are associated with Trommald and Hibbing soils. They are better drained than Trommald soils and more brown and reddish. They are of minor extent in Crow Wing County and of minor agricultural importance.

Profile of Zim silt loam in an undisturbed area (center of NW $\frac{1}{4}$  sec. 2, T. 46 N., R. 28 W.):

A0—2 inches to 0, finely divided organic matter; firm.

A1—0 to 1 inch, black (10YR 2/1) silt loam; moderate, very fine, granular structure; friable; roots plentiful; neutral to slightly acid; clear, smooth boundary.

A21—1 to 3 inches, light brownish-gray (2.5Y 6/2) silt loam; weak, very thin, platy structure; friable; many roots; many bleached sand grains; slightly acid to medium acid; gradual, smooth boundary.

A22g—3 to 6 inches, grayish-brown (2.5Y 5/2) silt loam with common, fine, faint mottles of light yellowish brown (2.5Y 6/4); weak to moderate, medium, subangular blocky structure; firm; few roots; bleached sand grains few or lacking; strongly acid; gradual, smooth boundary.

B1g—6 to 10 inches, grayish-brown (2.5Y 5/2) silt loam with common, fine, faint mottles of light yellowish brown (2.5Y 6/4); strong, medium, subangular blocky structure; firm; medium acid; gradual, smooth boundary.

B21g—10 to 18 inches, grayish-brown (2.5Y 5/2) silty clay loam; strong, medium, subangular to angular blocky structure; very firm; discontinuous clay films; medium acid; gradual boundary.

B22g—18 to 27 inches, brown (7.5Y 5/2) to dark-brown (7.5YR 4/2) silty clay; moderate, medium, prismatic structure that breaks to strong, medium, angular blocky; very firm; discontinuous clay films; strongly acid; gradual, smooth boundary.

B3—27 to 36 inches, brown (7.5YR 5/3) silty clay with many, medium, distinct mottles of strong brown (7.5YR 5/8); strong, medium, subangular blocky structure; very firm; strongly acid.

C—36 inches +, dark-brown (10YR 4/3) clay; massive; neutral; calcareous at about 48 inches.

*Range in characteristics:* The texture of the A1 horizon ranges from silt loam to silty clay loam. Hues in the C horizon range from 10YR to 2.5YR.



## General Nature of the County

Crow Wing County is near the geographic center of Minnesota. It is adjoined by Aitkin, Mille Lacs, Morrison, and Cass Counties.

In 1960, the population was 32,134. Of this number 16,607 was rural and 15,527 was urban. Brainerd, the county seat and largest city, had a population of 12,898. The county is a popular summer recreation area because of its many lakes. Consequently, there is a great influx of people during the summer.

## Geology

Two kinds of glacial till, of slightly different age and markedly different composition, have been deposited in the county. The older is middle Wisconsin (Cary) till, referred to as brown sandy till. This material has a sandy loam texture and is usually compact. It occurs mainly in two drumlin areas. One area, in the southern part of the county, is south and east of Brainerd. The other, in the northern part, is north of Whitefish Lake.

The more recent till was deposited during the late Wisconsin (Mankato) glacial age. This material is normally fine textured; it is referred to as red clay till. It occurs in the morainic region in the eastern part of the county, along the northern and southern shores of Mille Lacs Lake.

Gravelly and sandy outwash also occur in the county. The outwash is a mixture of material of both Cary age and Mankato age. A sizable area of well-sorted sandy outwash borders the Mississippi River. Some dunes have formed in this area.

## Vegetation

Most of the soils in the county formed under forest vegetation. The only prairie was on the outwash flats, east of Crow Wing and Fort Ripley. The vegetation consisted mainly of white pine, red pine, and jack pine but included some spruce and fir. Jack pine still flourishes on the sandy soils; many trees are cut each year for pulpwood and lumber. Otherwise, aspen and scrub red oak have replaced the original species.

## Agriculture

The U.S. Census of Agriculture, in 1959, reported 181,678 acres of farmland in Crow Wing County. This acreage is about one-tenth of the county. There were 1,001 farms in 1959. Of these, 313 were dairy farms; 110 were livestock farms; 16 were poultry farms; 10 were cash grain farms; and the rest were miscellaneous or unclassified farms.

Full owners operated 70 percent of the farms, and part owners 26 percent. The rest were tenant operated.

The number of larger farms in the county has increased since 1950, and the number of smaller farms has decreased. In 1959 the farms of the county averaged 182 acres in size. The distribution was as follows:

Acres	Number
Less than 10.....	12
10 to 50.....	114
50 to 100.....	205
100 to 180.....	272
180 to 260.....	184
260 to 500.....	179
500 to 1000.....	34
More than 1000.....	1

A large acreage is used for the forage crops needed to support livestock, and an even larger acreage is used as woodland. In 1959, about 68,931 acres of farmland was in pasture and about 77,666 acres was wooded. Some areas that are in pasture are also used for tree production.

The acreages of the major crops in stated years are shown in table 7. Hay and small grains are the most important crops. Corn is a principal crop, but the short growing season does not always allow it to mature. Only slightly more than half of the corn grown in the county is used for grain; most of the rest is used for silage. Most of the hay is a mixture of legumes and grasses, but some may be mostly grasses.

The livestock population of the county in stated years is given in table 8. Almost all of the farms in the county keep livestock, but only a few specialize in one kind of livestock.

TABLE 7.—*Acreages of principal crops in stated years*

Crop	1939	1949	1959
Corn for all purposes.....	13, 754	13, 284	13, 071
Corn harvested for grain.....	8, 192	8, 314	7, 031
Oats.....	7, 265	10, 357	9, 393
Wheat.....	298	226	50
Rye.....	3, 168	803	201
Hay.....	39, 353	38, 888	27, 496

TABLE 8.—*Number of livestock on farms in stated years*

Livestock	1940	1950	1960
Cattle and calves.....	18, 642	18, 160	15, 237
Horses and mules.....	3, 746	2, 047	521
Hogs and pigs.....	2, 867	5, 916	9, 496
Sheep and lambs.....	6, 941	5, 666	5, 737

## Water Supply

Wells in the glacial drift supply the county with drinking water. These wells range from 15 feet to 200 feet in depth. Wells in the sandy outwash need to be only 20 to 40 feet deep to furnish ample water for farm use. Livestock drink at ponds and streams during the frost-free period.

## Climate

Crow Wing County has a continental climate. Summers are warm and relatively short, and winters are cold and long. About 80 percent of the precipitation falls during the frost-free period. The northern part of the county is colder than the southern part, and it gets more

TABLE 9.—*Temperature and precipitation*

Month	Pine River Dam weather station (Elevation, 1,251 feet) (Data for northern part of county)						Brainerd weather station (Elevation, 1,215 feet) (Data for southern part of county)					
	Temperature			Precipitation			Temperature			Precipitation		
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1936)	Wettest year (1903)	Average	Absolute maximum	Absolute minimum	Average	Driest year (1936)	Wettest year (1899)
	°F.	°F.	°F.	Inches	Inches	Inches	°F.	°F.	°F.	Inches	Inches	Inches
January.....	8.0	52	—53	0.77	0.42	0.38	8.7	59	—42	0.83	0.59	0.20
February.....	11.5	55	—50	.72	.73	.52	13.4	57	—41	.75	1.16	.39
March.....	23.2	82	—41	1.30	.70	1.83	25.1	85	—35	1.09	.53	.65
April.....	40.1	93	—3	2.24	1.66	4.23	42.2	93	0	2.00	.92	2.80
May.....	53.3	103	4	3.67	2.96	4.42	55.1	106	19	3.26	2.28	4.92
June.....	63.0	100	24	4.35	1.41	1.46	64.7	103	21	4.00	1.11	7.46
July.....	68.8	104	32	3.34	.24	5.60	70.3	106	40	3.15	.63	2.13
August.....	65.9	100	29	3.94	1.81	7.60	67.5	104	34	4.18	1.92	9.66
September.....	56.5	99	17	2.36	1.71	6.75	57.9	104	19	1.96	3.02	2.60
October.....	45.6	87	0	1.86	.47	5.98	46.6	89	10	1.73	.38	3.81
November.....	28.5	76	—21	1.29	1.08	.19	28.8	75	—16	1.13	1.42	.16
December.....	14.2	66	—47	.70	1.62	.67	15.1	67	—39	.66	1.85	1.14
Year.....	39.9	104	—53	26.54	14.81	39.63	41.3	106	—42	24.74	15.81	35.92

precipitation. Table 9 shows summarized climatic data for the northern part of the county, recorded at the Pine River Dam weather station, and for the southern part, recorded at the Brainerd weather station. The data show that the average annual temperature in the northern part of the county is 1.4 degrees lower than that in the southern part, and that the annual precipitation in the northern part exceeds that in the southern part by 1.8 inches.

It is helpful to farmers to know the chances that temperatures low enough to damage or destroy plants will occur after any given date in spring and before any given date in fall. Table 10 shows the probability that temperatures of 32° F. (tender crops freeze at 32° F.) or lower and

28° F. (hardy crops can endure temperatures down to 28° F.) or lower will occur in Crow Wing County after stated dates in spring and before stated dates in fall. For example, there is a 10-percent chance that a temperature of 32° or lower will occur on or after June 9 in the northern part of the county and on or after May 30 in the southern part. Similarly, there is a 50-percent chance that a temperature of 28° or lower will occur on or before September 28 in the northern part of the county and on or before September 30 in the southern part.

Data recorded at the Pine River Dam and the Brainerd weather stations show that the growing season is shorter by approximately 23 days in the northern part of the

TABLE 10.—*Probability of freezing temperature on or after a given date in spring and on or before a given date in fall*  
[Based on University of Minnesota Agricultural Experiment Station Technical Bulletin 243, March 1963, by D. G. Baker and J. H. Strub, Jr.]

Probability	Pine River Dam weather station (Elevation, 1,251 feet) (Data for northern part of county)				Brainerd weather station (Elevation, 1,215 feet) (Data for southern part of county)			
	Spring temperature of—		Fall temperature of—		Spring temperature of—		Fall temperature of—	
	28°F. or lower	32°F. or lower	28°F. or lower	32°F. or lower	28°F. or lower	32°F. or lower	28°F. or lower	32°F. or lower
Percent								
10.....	May 28	June 9	Sept. 13	Aug. 30	May 17	May 30	Sept. 17	Sept. 13
20.....	May 22	June 3	Sept. 18	Sept. 5	May 13	May 25	Sept. 22	Sept. 17
30.....	May 19	May 30	Sept. 22	Sept. 9	May 10	May 22	Sept. 25	Sept. 19
40.....	May 16	May 27	Sept. 25	Sept. 13	May 7	May 19	Sept. 28	Sept. 22
50.....	May 13	May 24	Sept. 28	Sept. 16	May 4	May 16	Sept. 30	Sept. 24
60.....	May 10	May 21	Oct. 1	Sept. 19	May 2	May 13	Oct. 2	Sept. 26
70.....	May 7	May 18	Oct. 4	Sept. 23	April 27	May 10	Oct. 5	Sept. 28
80.....	May 4	May 14	Oct. 8	Sept. 27	April 26	May 6	Oct. 8	Sept. 30
90.....	April 28	May 8	Oct. 13	Oct. 3	April 21	May 1	Oct. 13	Oct. 4



county than in the southern part. A frost-free season (temperatures of 33° F. and above) of only 90 days has been recorded at the Pine River Dam station 90 percent of the time, but a frost-free season of 113 days has been recorded at the Brainerd station 90 percent of the time. Table 11 shows the average commencement date of agricultural seasons in Crow Wing County.

TABLE 11.—Average commencement date of agricultural seasons

[Based on University of Minnesota Agricultural Experiment Station Technical Bulletin 245, June 1963, by D. G. Baker and J. H. Strub, Jr.]

Season	Pine River Dam weather station (Elevation, 1,251 feet) (Data for northern part of county)	Brainerd weather station (Elevation, 1,215 feet) (Data for southern part of county)
Early spring: cool-season annuals planted; cool-season perennials begin to grow.	April 22	April 13.
Late spring: warm-season crops planted; cool-season crops begin to grow rapidly.	June 4	May 26.
Summer: small grains harvested; warm-season crops begin to grow rapidly.	June 26	( <sup>1</sup> ).
Early fall: cool-season, winter annuals planted; warm-season crops begin to mature rapidly.	July 27	( <sup>1</sup> ).
Late fall: warm-season annuals harvested; cool-season, winter annuals begin to grow rapidly.	August 31	September 14.
Winter: cultivated crops cease to grow.	October 21	October 28.

<sup>1</sup> Data not available.

## Glossary

**Aeration, soil.** The exchange of air in the soil with air from the atmosphere.

**Aggregate, soil.** Many fine soil particles held together by internal forces in a granule, clod, block, crumb, prism, or other single mass or cluster.

**Available moisture capacity.** The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

**Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

*Loose.*—Noncoherent; will not hold together in a mass.

*Friable.*—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

*Firm.*—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

*Plastic.*—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

*Sticky.*—When wet, adheres to other material, and tends to stretch somewhat and pull apart rather than to pull free from other material.

*Hard.*—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

*Soft.*—When dry, breaks into powder or individual grains under very slight pressure.

*Cemented.*—Hard and brittle; little affected by moistening.

**Gravel.** Rounded or subrounded rock fragments or other coarse mineral particles ranging from 2 millimeters to 3 inches in diameter.

**Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

**Loam.** The textural class name for soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

**Mottled.** Irregularly marked with spots of different colors. Mottling in soils usually indicates poor drainage. Descriptive terms for mottles are as follows: Contrast—*faint, distinct, and prominent*; abundance—*few, common, and many*; and size—*fine, medium, and coarse*.

Size measurements for mottles are as follows: *Fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

**Permeability, soil.** That quality of a soil that enables water and air to move through it. Terms used to describe permeability are as follows: *Very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid*.

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.

**Reaction, soil.** The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction, because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. The degrees of acidity or alkalinity are expressed thus:

	pH		pH
Extremely acid	Below 4.5	Mildly alkaline	7.4–7.8
Very strongly acid	4.5–5.0	Moderately alkaline	7.9–8.4
Strongly acid	5.1–5.5	Strongly alkaline	8.5–9.0
Medium acid	5.6–6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1–6.5		
Neutral	6.6–7.3		

**Sand.** As a soil separate, individual rock or mineral fragments that range from 0.05 millimeter (0.002 inch) to 2.0 millimeters (0.079 inch) in diameter. Sand grains consist chiefly of quartz, but they may be of any mineral composition. As a textural class, soil material that is 85 percent or more sand and not more than 10 percent clay.

**Silt.** As a soil separate, individual mineral particles that range from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter) in diameter. As a textural class, soil material that is 80 percent or more silt and less than 12 percent clay.

**Single-grain soil.** A structureless soil in which each particle exists separately.

**Soil.** The natural medium for growth of land plants; a natural three-dimensional body on the earth's surface that has properties resulting from the integrated effects of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soils includes the A and B horizons. Usually, the characteristics of the material in these horizons are unlike those of the underlying parent material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy, prismatic, columnar, blocky, and granular*. Structure is defined in terms of distinctness,

size, and shape of the soil aggregates; for example, "moderate, medium, subangular blocky" means moderately distinct, medium-sized aggregates of subangular blocky shape.

**Subsoil.** Technically, the B horizon of soils with distinct profiles; roughly, that part of the profile below plow depth.

**Subsurface soil.** As used in this report, that part of the A horizon below the surface layer.

**Surface layer.** As used in this report, the uppermost layer of the soil.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness.

**Texture, soil.** The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are as follows: *Sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."



# GUIDE TO RECONNAISSANCE MAPPING UNITS

[Soils surveyed by reconnaissance method were not placed in interpretative groups; see table 2, p. 14 , for approximate acreage and proportionate extent of the soil associations]

Map symbol	Mapping unit	Page
AD	Alluvial land-----	14
BCA	Brainerd-Chetek Association, nearly level-----	14
BCB	Brainerd-Chetek Association, undulating-----	14
BCC	Brainerd-Chetek Association, rolling-----	14
BNB	Brainerd-Nokay Association, undulating-----	14
BNC	Brainerd-Nokay Association, rolling-----	14
COA	Chetek-Onamia Association, nearly level-----	14
COB	Chetek-Onamia Association, undulating-----	15
COC	Chetek-Onamia Association, rolling-----	15
DCA	Dean Lake-Croswell Association, nearly level-----	15
DP	Dean Lake-Peat Association-----	15
HAB	Hibbing Association, undulating-----	15
HAC	Hibbing Association, rolling-----	15
HCB	Hibbing-Chetek Association, undulating-----	15
HCC	Hibbing-Chetek Association, rolling-----	15
HDA	Hubbard Association, nearly level-----	15
HDB	Hubbard Association, undulating-----	15
HZA	Hibbing-Zim Association, nearly level-----	15
ID	Iosco-Dean Lake Association-----	15
LB	Lake beaches-----	15
LP	Lino-Peat Association-----	15
MCA	Menahga-Croswell Association, nearly level-----	15
MNA	Menahga-Nymore Association, nearly level-----	15
MNB	Menahga-Nymore Association, undulating-----	16
MNC	Menahga-Nymore Association, rolling-----	16
MR	Marsh-----	15
NBA	Nokay-Brainerd Association, nearly level-----	16
NM	Nisswa-Merrifield Association-----	16
NP	Nokay-Peat Association-----	16
NW	Nokay-Warman-Peat Association-----	16
P	Peat-----	16
TP	Trommald-Peat Association-----	16
WP	Warman-Halder-Peat Association-----	16

# GUIDE TO DETAILED MAPPING UNITS

[See table 1, p. 10 , for approximate acreage and proportionate extent of the soils; table 3, p. 22 , for expectable acreage acre yields; and the section beginning on p. 25, for information significant to soil engineering]

Map Symbol	Mapping unit	Page	Management group		Woodland group	
			Number	Page	Number	Page
Ad	Alluvial land-----	11	15	21	9	24
Ba	Barrows loam and sandy loam-----	11	13	21	9	24
BbA	Brainerd sandy loam, 0 to 2 percent slopes-----	11	1	19	5	24
BbB	Brainerd sandy loam, 2 to 7 percent slopes-----	11	1	19	5	24
BbC	Brainerd sandy loam, 7 to 13 percent slopes-----	11	4	19	5	24
BcB	Brainerd-Chetek complex, 2 to 7 percent slopes-----	11	5	20	5	24
BcC	Brainerd-Chetek complex, 7 to 13 percent slopes-----	11	11	20	5	24
BuA	Burkhardt sandy loam, 0 to 2 percent slopes-----	11	7	20	2	24
BuB	Burkhardt sandy loam, 2 to 7 percent slopes-----	11	5	20	2	24
CgA	Chetek gravelly loamy sand, 0 to 2 percent slopes----	11	12	20	3	24
ChA	Chetek sandy loam, 0 to 2 percent slopes-----	11	7	20	1	23
ChB	Chetek sandy loam, 2 to 7 percent slopes-----	11	5	20	1	23
ChC	Chetek sandy loam, 7 to 13 percent slopes-----	11	11	20	1	23
ChD	Chetek sandy loam, 13 to 18 percent slopes-----	11	16	21	1	23
ChE	Chetek sandy loam, 18 to 30 percent slopes-----	12	18	21	1	23
Ha	Halder loam-----	12	3	19	6	24
HbB	Hibbing silt loam, 2 to 7 percent slopes-----	12	2	19	7	24
HbC	Hibbing silt loam, 7 to 13 percent slopes-----	12	6	20	7	24
HuA	Hubbard loamy sand, 0 to 2 percent slopes-----	12	12	20	3	24
HuA2	Hubbard loamy sand, 0 to 2 percent slopes, moderately wind eroded-----	12	12	20	3	24
HuB	Hubbard loamy sand, 2 to 7 percent slopes-----	12	12	20	3	24
HuC	Hubbard loamy sand, 7 to 13 percent slopes-----	12	17	21	3	24
Io	Iosco loamy sand, shallow-----	12	9	20	10	25
Is	Isanti sandy loam-----	12	13	21	9	24
Lb	Lake beaches-----	12	12	20	3	24
Lo	Lino loamy sand-----	12	9	20	10	25
MaA	Menahga loamy sand and sand, 0 to 2 percent slopes---	12	12	20	3	24
MaB	Menahga loamy sand and sand, 2 to 7 percent slopes---	12	12	20	3	24
MaC	Menahga loamy sand and sand, 7 to 13 percent slopes--	12	17	21	3	24
Mr	Marsh-----	12	19	21	11	25
Nk	Nokasippi sandy loam-----	12	13	21	9	24
NoA	Nokay sandy loam, 0 to 2 percent slopes-----	13	3	19	6	24
NoB	Nokay sandy loam, 2 to 7 percent slopes-----	13	3	19	6	24
NyA	Nymore loamy sand, 0 to 2 percent slopes-----	13	12	20	3	24
NyB	Nymore loamy sand, 2 to 7 percent slopes-----	13	12	20	3	24
NyC	Nymore loamy sand, 7 to 13 percent slopes-----	13	17	21	3	24
OnA	Onamia sandy loam, 0 to 2 percent slopes-----	13	7	20	2	24
OnB	Onamia sandy loam, 2 to 7 percent slopes-----	13	5	20	2	24
OnC	Onamia sandy loam, 7 to 13 percent slopes-----	13	11	20	2	24
Pa	Peat, deep-----	13	14	21	11	25
Pc	Peat, moderately shallow over clays-----	13	14	21	11	25
Pg	Peat, moderately shallow over sands-----	13	15	21	11	25
PoA	Pomroy loamy sand, 0 to 2 percent slopes-----	13	8	20	4	24
PoB	Pomroy loamy sand, 2 to 7 percent slopes-----	13	8	20	4	24
PoC	Pomroy loamy sand, 7 to 13 percent slopes-----	13	11	20	4	24
PoD	Pomroy loamy sand, 13 to 18 percent slopes-----	13	16	21	4	24
Wa	Warman loam-----	13	13	21	9	24
Wt	Watab loamy sand-----	14	9	20	10	25
Zc	Zim silty clay loam-----	14	10	20	8	24



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